POWER

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Getting Along

"THE error which was made in times past in allowing the ownership of the coal to fall into private hands should be retrieved. The mineral should be acquired by the state."—*Report of the British Royal Coal Commission.*

"The President of the United States should be authorized by act of Congress to declare that a national emergency exists whenever, through failure of operators and miners in the anthracite industry to agree upon the terms of employment or for any other reason, there is a suspension of 'mining operations, seriously interrupting the normal supply of anthracite fuel in interstate commerce, and to take over the operation of the mines and the transportation, distribution and marketing of the product, with full power to determine the wages to be paid to mine workers, the prices at which the coal shall be sold and, subject to court review, the compensation to be paid to land owners and mine owners."—*Report of United States Coal Commission.*

"Under the bill reported by the Senate Committee on Education and Labor the President would be authorized and empowered in the event of a coal strike, should it become apparent that the strike threatens the health, safety and welfare of the people.

"He would also be given power to take over and operate, directly or by lease, such coal mines as may be necessary to provide for the production and distribution of coal at reasonable prices and of a quality adequate to supply the needs of the people."—*Daily Press.*

Any action, past or present or contemplated, that gives to any man or any group of men the opportunity or power to exploit a natural resource or public privilege for more than a fair return upon the money actually invested in it, a fair profit upon initiative and enterprise and a fair remuneration for labor, executive or manual, actually performed, is a mistake.

Vide the coal situation—British and otherwise.

F. R. Low

The South Comes to the Front in Power Developments

By L. H. MORRISON
Editorial Staff, *Power*

BOTH industrial power plants and central stations of modern design are being installed. Bleeder turbines are favored in textile mills. Southern rivers are being intensely developed for hydro-electric power. Florida's late boom tripled the power demand.

PROBABLY no part of the country is experiencing the amount of power expansion that is in evidence in the Southeast, including Virginia, North and South Carolina, Georgia and Florida.

The South until recent years devoted its attention almost exclusively to agriculture, to the general exclusion of engineering and industrial activities; success in life lay in banking and planting lines. This condition deterred those of means from engaging in manufacturing, and the opportunity for the unskilled classes to eke out a bare livelihood rested almost exclusively in tenant farming and personal service. Of late years this condition has been overturned, and with factories springing up on all sides the demand for labor and for power has increased many fold.

Plants in Virginia

Virginia, of all the Southeastern States, has been slowest to awaken to its industrial possibilities, although at Danville and elsewhere textile mills have been in operation for years.

At Richmond a few mills have their own generating units, but most of the power demands are met by the Virginia Railway & Power Co. This public utility operates a hydro-electric plant of nine wheels, taking water from the James River through a canal originally built to pass boats around the shoals at Richmond. The station proved insufficient to meet the demands and a steam plant containing three turbo-generator sets has been erected on adjoining property. At present, another hydro-electric plant is being built across the river from the city, where water is available through a second canal now serving industrial plants. The plants of this public utility are connected with a transmission line serving Petersburg and other cities.

A transmission line connecting Richmond with Fredericksburg, Va., is being built by the Virginia Electric & Power Co. The new link will make it possible to utilize the entire hydro-electric capacity at Fredericksburg, and the steam station at Richmond will provide service to the entire territory during low-water periods. The towns of Milford and Bowling Green, Va., will also be served from this 66,000-volt line, which will ultimately be opened at 114,000 volts. The hydro-electric plant at Fredericksburg will be extended, increasing the capacity more than a thousand horsepower. The generating equipment will be changed from 25 to 60 cycles in order to improve lighting and power service and to have a standard frequency.

Electrification of the Virginia Railway necessitated the construction of a power plant. As coal was available at low cost, the plant was erected at Narrows, Va., and contained five 15,000-sq.ft. water-tube boilers burning pulverized coal, while the turbo-units are rated at 12,500 kw. each.

The Merchants Ice & Cold Storage Co. has remodeled its Richmond plant, installing a uniflow engine direct-connected to a horizontal double-acting compressor, and a uniflow direct-connected to a generator to supply power to the motorized auxiliaries. Centrifugal pumps were installed wherever it was possible to eliminate steam-driven duplex units.

An interesting combination of an oil engine and two waterwheels is found in the Charlottesville Woolen Mills.

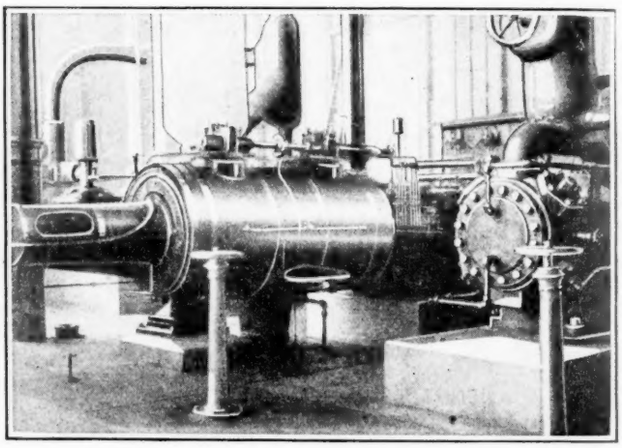


Fig. 1—Uniflow engine driving high-speed compressor in Virginia refrigerating plant

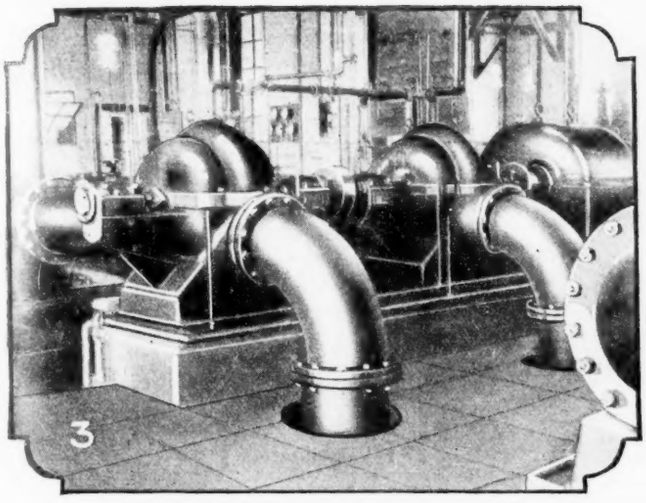
This was described in *Power*, March 2. Rayon silk mills are being established in several towns, and by reason of a supply of low-priced coal and availability of labor Virginia will undoubtedly show a decided industrial trend in the next ten years.

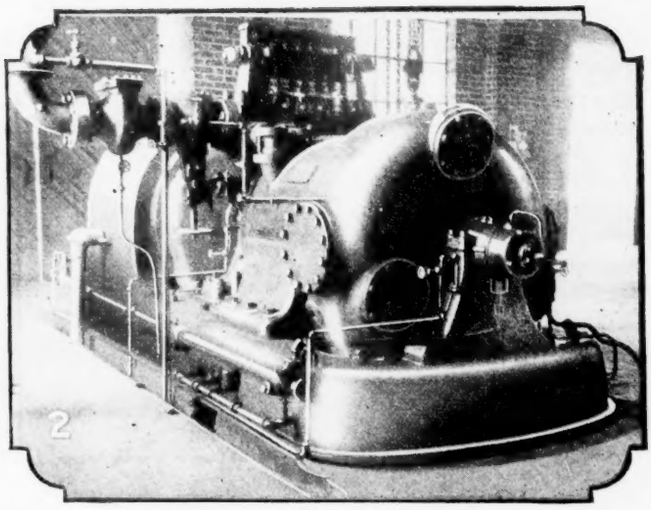
The Carolinas

North and South Carolina, from an engineering viewpoint, are the most interesting of the South Atlantic States. Textile mills are found in almost every town in the central and western parts of both states. In many localities there are scores of such mills gathered about a city, each mill seated in the center of its own town, which is owned and controlled by the mill. It is estimated that of the 45 million spindles in operation in this country over 11 million are in the Carolinas.

These spinning mills have but little use for exhaust steam, and this led to the use of purchased power when it was available. Other mills, when erected 10 or 20 years ago, installed condensing Corliss engines, but many of these were shut down when coal prices became high.

Unfortunately, water shortages caused several of the





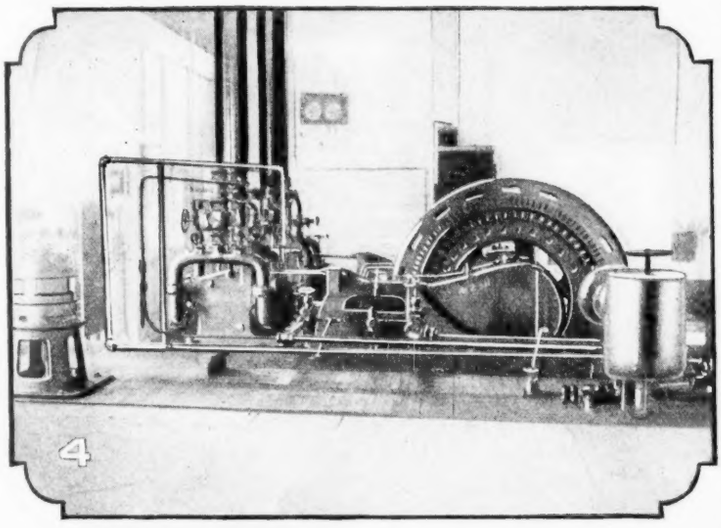
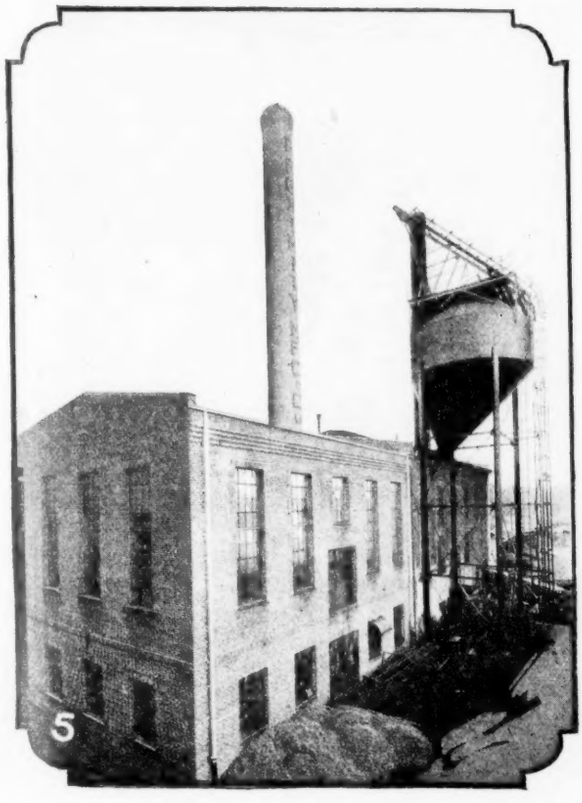
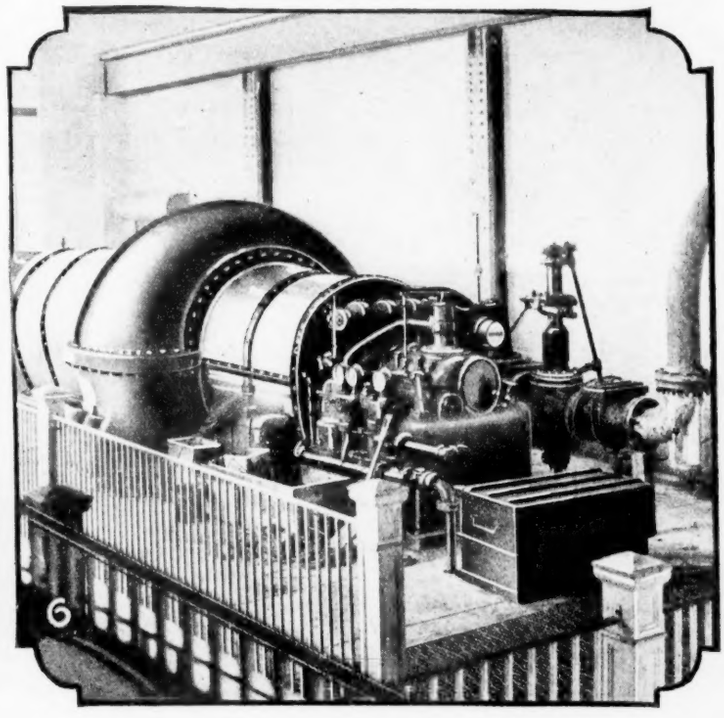


Fig. 2—Small steam stand-by plant
Fig. 3—Turbine-driven pump at Greensboro
Fig. 4—Motor-driven refrigerating machine at Baltimore
Fig. 5—Coal equipment at Proximity mills
Fig. 6—Rocky Mount installs 2,500-kw. plant





hydro-electric plants to curtail their outputs, and last summer practically all the textile mills ran on short time. This awakened mill owners to the desirability of continual power, and the tendency is now toward the installation of prime movers at the mills. While a few reciprocating engines have been installed, condensing turbines are in the preponderancy.

Where process steam is required, bleeder turbines are being installed, steam being extracted at pressures varying from 15 to 50 lb. gage. Among the textile mills in North Carolina installing power plants during the last 12 months are the Balfour mills at Smyth, the Proximity mills at Greensboro, and the Biltmore-Sayles Bleachery at Biltmore.

Many refrigerating plants have either had their capacity increased or entirely new plants built. The tendency is toward the use of purchased power, with the compressor direct connected to synchronous motors.

At Winston-Salem, N. C., the Reynolds Tobacco Co. has several power plants with factory buildings grouped about each generating station. The engines' loads are regulated to give the supplies of exhaust steam needed by the particular groups, the remainder of the load being carried by a bleeder-turbine station. This company is now installing a 5,000-kw. central station to supply electric energy and exhaust steam to all the factories.

Steam Units in Favor

Many of the smaller municipalities make use of oil engines in the light and water plants, but in the main the high oil prices and availability of cheap coal have prompted the use of steam units. A striking example of a modern municipal undertaking is the new light plant at Rocky Mount, N. C., where high-pressure boilers, stoker-fired superheaters, centrifugal feed pumps and a high-efficiency steam turbine have just been put into service.

In the central and eastern part of the state the North Carolina Light & Power Co. has several hydro-electric stations and steam stand-by plants, the largest of which, the Cape Fear River plant of 70,000 kw., was completed about two years ago.

The possibilities of the Carolina rivers were early recognized, and along the Catawba River which runs through both the Carolinas the Southern Power Co. has installed a total capacity of 453,425 kw. The primary water storage is at Bridgewater, where the wheel capacity is 25,000 kw. At present the company has ten hydro-electric plants along this river, the last to go into commission being Catawba station just across the state line in South Carolina, containing four units totaling 70,000 kw. capacity. The development of the Catawba probably exceeds that of any other river. The elevation above sea level of the intake at Bridgewater is 1,200 ft., while that of the tailrace at the lowest plant, which is at Wateree, S. C., is 140 ft., or a total available head of 1,060 ft. The ten hydro stations make use of a total of 688 ft.; in other words the percentage of head use is over 64 per cent. The watershed at Bridgewater is 640 square miles and at Wateree it is 6,000. The variation in water flow has necessitated the installation of steam stand-by stations. These at present total 130,250 kw., and the Southern Power Co. is now constructing a 70,000-kw. steam plant at Bucks, N. C., using pulverized coal for fuel.

South Carolina has not shown as much industrial activity as has been experienced in North Carolina. However, the available water powers are being developed on rivers other than the Catawba, which is closely linked with the developments in North Carolina, and at Columbia, S. C., the Broad River Power Co. has put into commission a steam plant containing a 17,000-kw. turbo-generator unit, boilers, etc. This will serve as a stand-by for the hydro-electric plant at this point and will soon be increased by a like unit. It is the first Southern central station to use pulverized coal.

Broadly, the new textile mills needing but little process steam are buying electric power, while those, such as dye works, bleacheries, etc., whose process-steam requirements are large, are installing bleeder turbines. The tendency in such plants is toward the use of high-pressure boilers, stoker fired, and pulverized coal has not gained any great foothold in Southern mills. This is traceable to the feeling that the required skilled boiler-room help is not available.

Hydro-Electric Power in Georgia

In Georgia the largest hydro development is at Tullulah Falls, where the Georgia Railway & Power Co. has six 18,000-hp. hydraulic turbines direct connected to 12,000-kw. generators. At Tugalo, just below the junction of the Tullulah and Chattanooga rivers, this company erected a plant containing four 22,000-hp. wheels which was put into service in 1924. Work has been completed on two other developments, known as the Terrora and Yonah projects. The latter installation consists of three 12,500-hp. vertical wheels located three miles below the Tugalo plant. The dam is 73 ft. high and 900 ft. long. The Terrora plant has a capacity of 20,000 kw. and is at the upper end of Tullulah Lake.

Plans are in progress for an increase in the hydro-electric plant at Dublin, Ga.

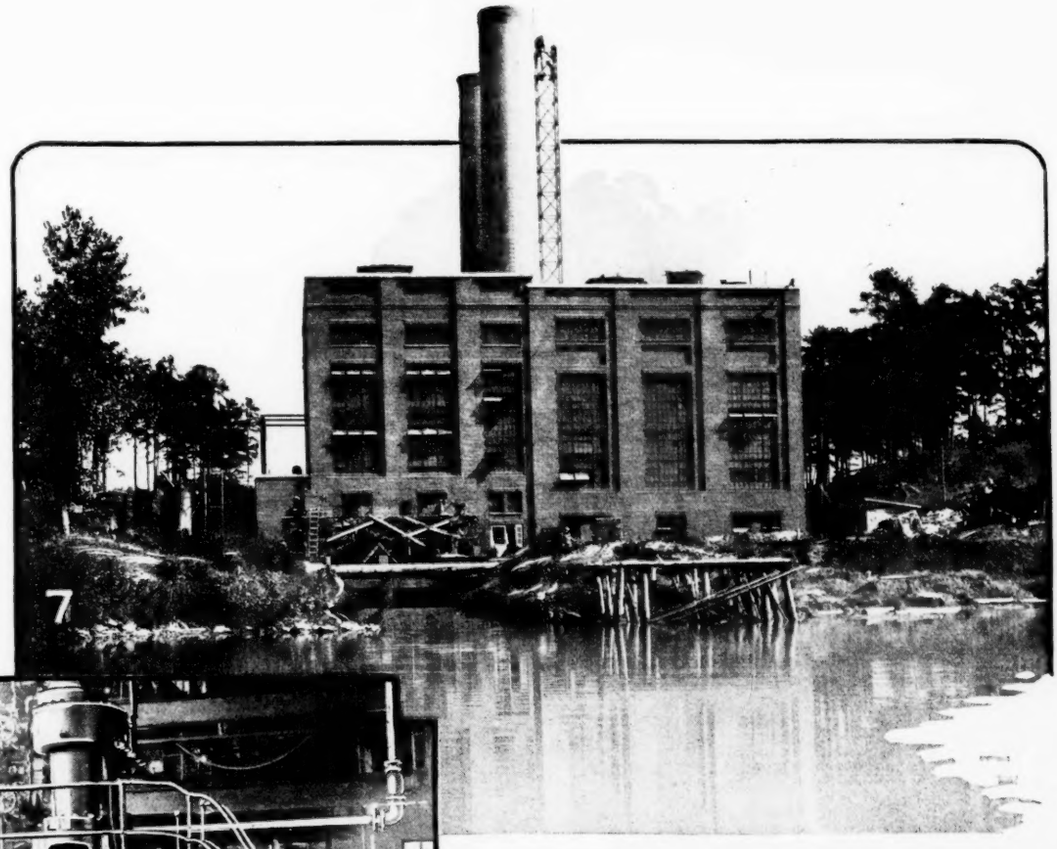
Taken as a whole, the industrial development of Georgia has been along the line of small factories, ice plants, brick plants, etc. Many of these purchase energy, the remainder making use of both steam and oil engines. Owing to the high cost of fuel oil in Georgia, the oil engine is by no means outstanding. Many of the smaller municipal light and water plants, however, have installed Diesel engines with satisfactory results. The trend, however, is to the use of purchased energy, and plans are now being worked out for the extension of the transmission line from the Albany hydro-electric plant to the Georgia-Florida border.

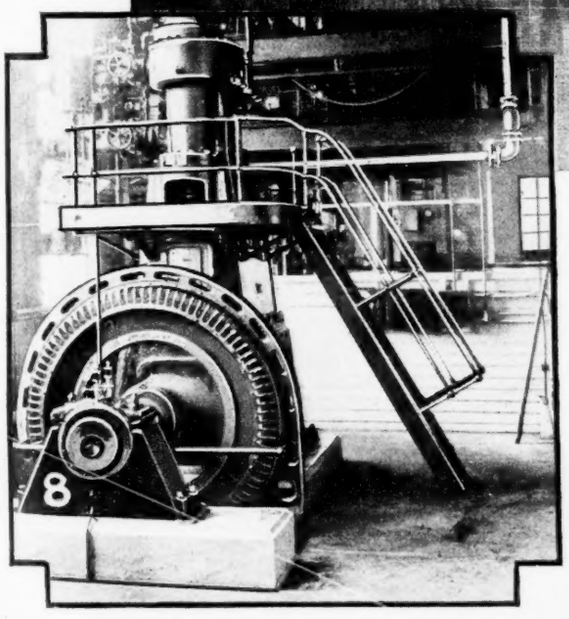
One cannot discuss Southern power developments without calling attention to the tremendous expansion of demand in Florida for power and light.

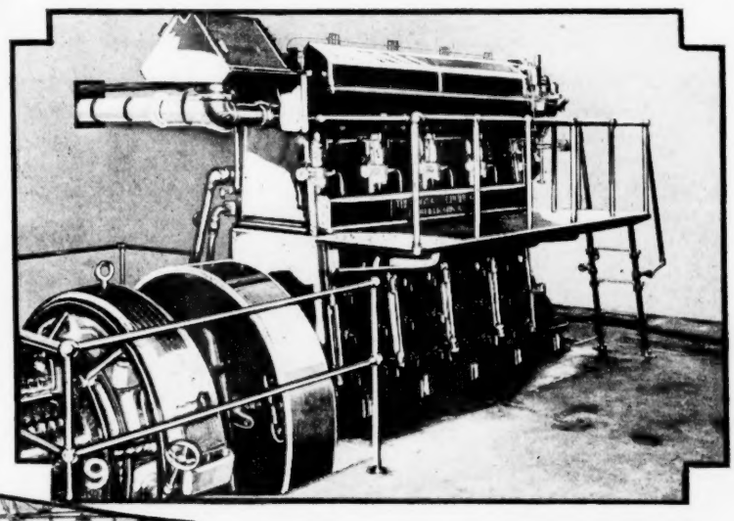
Florida Power Developments

The more important towns, such as Jacksonville, St. Augustine, Tampa, St. Petersburg, etc., are of some age and, consequently, when the land boom started a few years ago, these towns were in a position to meet the increase in electrical demands. This, of course, entailed enlargements in station equipment, but the organization was in existence, which, after all is more important than generally given credence.

The towns that sprang into existence by reason of the inrush of real estate operators and home seekers, were compelled to install both electric and water-pumping equipment. Necessarily, since the future rate of growth of a new town could not be predicted, the generating units first installed were of small capacity, additional







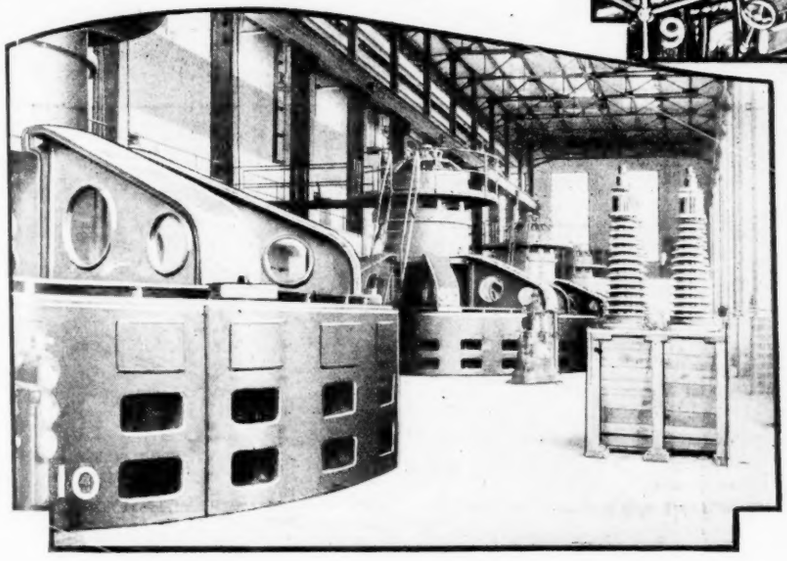
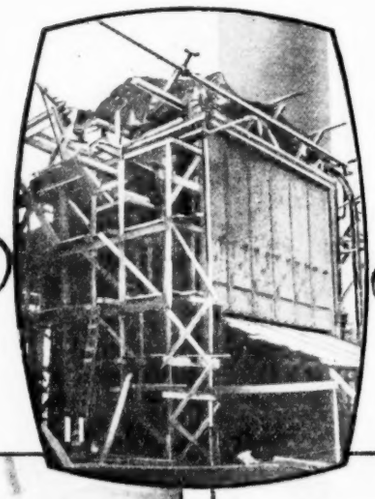


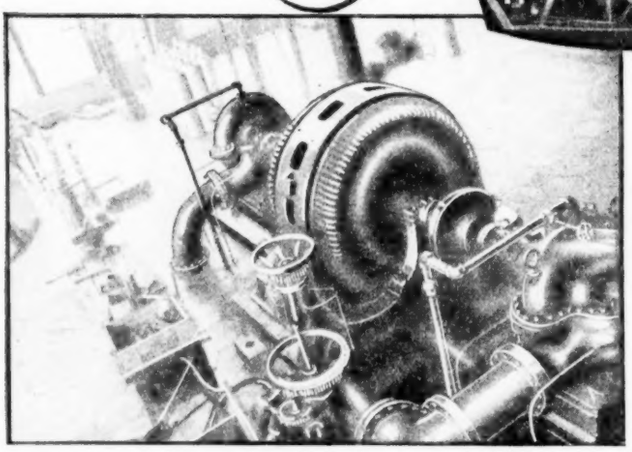
Fig. 7—Steam stand-by at Parr Shoais, S. C.

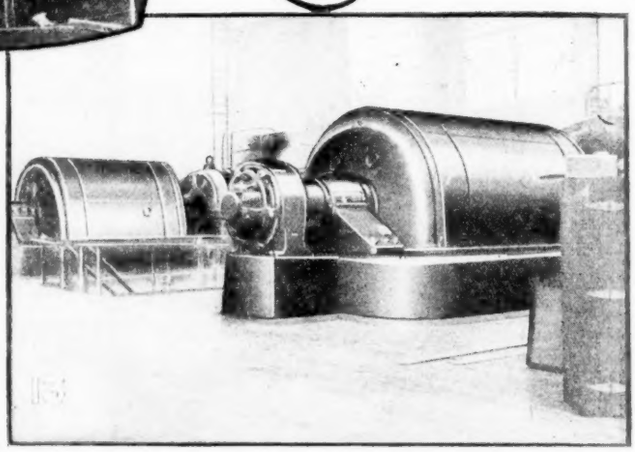
Fig. 8—Motorized compressor replaces steam units at Valdosta, Ga.,

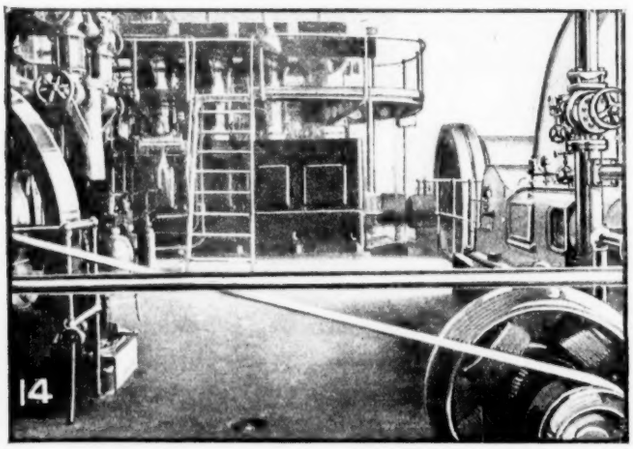
Fig. 9—Oil engine in Nashville, Ga., municipal plant

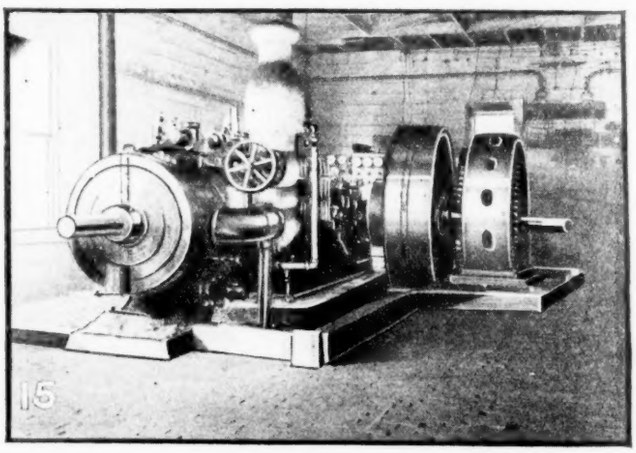
Fig. 10 — Hydro-electric plant at Catawba, S. C.

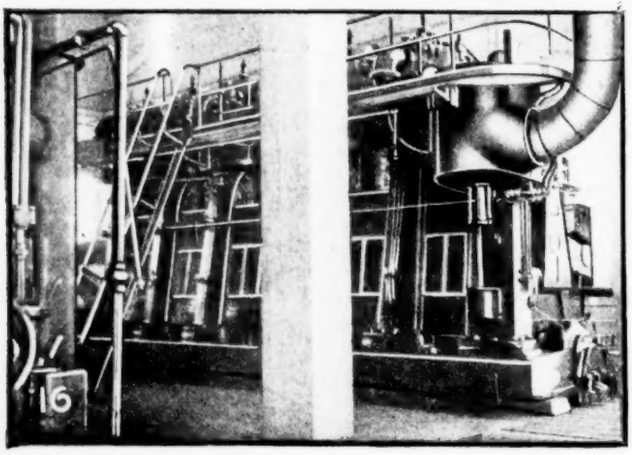












Florida Power Developments

Fig. 11—Boiler at Miami rushed into service

Fig. 12—Synchronous motor drives pumps at Jacksonville

Fig. 13—Turbines in Miami's new central station

Fig. 14—Oil engine drives ammonia compressor at St. Petersburg

Fig. 15—Uniflow engine unit at Lake City

Fig. 16—1,250-hp. Diesel at Hollywood

and larger ones being purchased from year to year as the demands increased.

Entering the state at the northeast, the first town of any size is Jacksonville, which has a municipal light plant and also water-works plants. The former is equipped with steam turbines totaling 28,000 kw. and oil-fired boilers. During the last year no new units have been installed, although the growth of the city will compel an additional turbine before another year. The water works contains two one-million gallon horizontal crank and flywheel Corliss pumping engines. Recently, two 24-in. horizontal centrifugal pumps direct connected to 350-hp. synchronous motors have been added.

At Daytona the existing plant contains a 1,500-kw. and a 500-kw. turbine, and since the city has begun to expand, a 3,125-kw. unit has been installed.

At new Smyrna a 400-hp. Diesel is being installed in the municipal light plant which contains, in addition, a smaller oil engine. Titusville, just south of New Smyrna, is likewise increasing its plant capacity by an 800-hp. oil-engine unit. At Cocoa the combined light and ice plant is owned by the Florida Power & Light Co. and now contains two Diesel-driven generators of 1,000 kw. total capacity.

The West Palm Beach plant of the Florida Power & Light Co. has not been enlarged, as it is the intention ultimately to erect a new station on Lake Worth, fronting Palm Beach.

The municipality of Lake Worth, just below Palm Beach, has just finished the installation of a second 1,000-hp. Diesel unit, making a total plant capacity of 2,400 hp.

Miami is of course the outstanding city of Florida. Its growth has been tremendous and the power demands correspondingly severe. This compelled the Florida Power & Light Co. to add a 15,000-kw. and a 12,500-kw. turbo-generator set to the plant, whose capacity was but 9,500 kw. Two new 15,000-sq.ft. boilers were also installed, equipped with oil burners and radiant superheaters. So urgent was the necessity of more boiler capacity that one was erected outside the building and operated several months before the building was extended.

Hollywood has by intensive publicity become known as the Florida resort. When first built in 1923 the electric light plant contained a 150-hp. two-stroke-cycle oil engine, but within a year three 300-hp. units were installed and in November, 1925, a 1,250-hp. two-stroke-cycle Diesel was put into service. The owner ordered two 2,250-hp. units, but upon the purchase of the plant by the Florida Power & Light Co. plans were prepared to install these units at Punta Gordo. Hollywood's additional requirements are being met by energy transmitted from Miami. The speed with which lines are constructed was strikingly shown during the hooking in of the Miami line. Four days after the decision to connect with the Miami line, four miles of steel towers and circuits were put in, transformer tanks placed and the systems connected.

At Fort Lauderdale the Florida Power & Light Co. is busy on the initial work of constructing a 60,000-kw. plant.

A new ice plant is also being erected at this place, containing two horizontal compressors driven by two-stroke-cycle oil engines.

At Siebring, west of Palm Beach, and at the lower end of the citrus country, an 800-hp. Diesel is being installed, while at Lakeland to the north the public utility is adding a 2,500-kw. unit to the existing plant. The ice plant owned by the Federal Ice Refrigerating Co., is driven by three four-stroke-cycle Diesels of 500 hp. each.

Kissimmee operates a municipal light plant. A few months ago a 750-hp. four-stroke-cycle Diesel was installed to be operated in conjunction with the two 300-hp. units in the plant.

Orlando is in the peculiar condition of having two distinct electrical systems. One, owned by the municipality, supplies energy to consumers within the corporate limits, while the second, owned by the Florida Public Service Co., supplies energy to outlying additions. No manufacturing industries exist here save ice plants. One of these, the Nye ice plant, is driven by a 330-hp. two-stroke-cycle Diesel, and another is to be added in a short time.

At Sanford the Florida Public Service Co. is installing a 12,500-kw. plant which is to have an ultimate capacity of 50,000 kw. This will be equipped for both pulverized coal and oil firing. This company has 270 miles of transmission lines and serves over 100 towns.

The new Sanford ice plant of the Federal Ice Refrigerating Co. has just gone into service. This contains four motor-driven compressors with a total capacity of 500 tons.

On the west coast the Tampa electric light plant has been increased from year to year. The city is at present busy constructing a new water pumping plant which will contain turbine-driven centrifugal pumps and oil-fired boilers.

The Citizens Ice & Cold Storage Co.'s plant at St. Petersburg has just had its capacity increased by an additional 400-hp. four-stroke-cycle Diesel. This engine is connected to a compressor through a rope drive and also carries a direct-connected generator.

In the northern part of the state two large Diesels are being installed at Perry to carry the electric lighting load.

Broadly speaking, power plants in Florida are devoted almost exclusively to the generation of electrical current for lighting and small motors, and to the driving of ice machines. Here and there, as is the case at Lake City, there is a large lumber mill, or a phosphate works as at Plant City, but otherwise manufacturers are notable by their absence.

The purchase of many of the smaller central stations by the three public service corporations operating in the state, foreshadows the shutdown of many of the small plants and the operation of a few large stations.

BRITISH PATENT SPECIFICATION No. 249,960, by G. and J. Weir, Ltd., and J. G. Weir, of Holm Foundry, Cathcart, Glasgow, Scotland, relates to an arrangement for recovering the latent heat of moisture in the combustion products of a steam generator. In one arrangement illustrated the fuel is burned in an inclosed furnace supplied with air under 10 lb. pressure, and the products of combustion passed from the first boiler to a second, in which the steam pressure is low enough to permit the vapor to condense. The steam from the first boiler may be conducted to the high-pressure stages of a turbine, the low-pressure stages being supplied from the second boiler through another pipe. The flue gases coming from the second boiler may be made to operate a turbine before passing to the chimney.

The Mercury-Steam Cycle

Why It Is Superior to Other Binary-Vapor Processes

BY P. M. SHEN

IN POWER generation efficiency is limited both by the cycle used and the working medium employed; any change in either will affect the operating efficiency of the prime mover. The binary-vapor conception is herein considered as a possible means of increasing efficiency.

The first application of this idea was in the design and construction of a binary engine in 1850 by M. du Tremblay. His engine was built for ship propulsion with the idea of increasing the economy and reducing the floor space necessary, but an accident, due to the inflammable character of sulphuric ether, which was employed as the working vapor in the low-pressure stage of the process, halted further progress along this line.

In fully utilizing the heat content of steam, vacuums have been persistently increased as the art of power generation developed. The reciprocating engine, which was in universal use until the early years of the present century, did not lend itself readily to this advance. In order to accommodate the enormous volume of steam at low pressures, the low-pressure engine cylinder was necessarily very large. As a result the increase in radiation losses, greater mechanical friction, difficulty in handling steam containing a large percentage of moisture, decrease in mean effective pressures and increase in cylinder condensation nullified any thermodynamic gain inherent in the higher vacuums.

AN IDEAL single fluid for power generation would give moderate pressures at high temperatures and moderate volumes at low temperatures. Since no such fluid exisits, there is a field for binary-vapor installations. All things considered, steam is the best available fluid for the lower range and mercury the best for the higher range. It is possible—though not certain—that the mercury-steam cycle which is being tried out at Hartford may work a revolution in power generation.

Because of this inability of the steam engine to utilize high vacuum, the binary-vapor idea was revived about 1900. Engines designed on this principle were, as a result of this revival, put into actual operation in a few German central stations.

The advent of the steam turbine, which could handle steam at low pressures to greater advantage, caused a second halt in the development of the binary-vapor process. The trend toward higher vacuums again continued its course until the present condition was reached; that is, the maximum vacuum attainable under ordinary cooling-water conditions was realized.

Carnot's basis for the comparison of the thermal efficiencies of various cycles is stated as follows:

$$Efficiency = \frac{T_1 - T_2}{T_1}$$

where T_1 is the absolute temperature at which the heat is absorbed and T_2 is the temperature at which it is rejected. It is obvious that an increase in efficiency can be effected by decreasing T_2 or by increasing T_1. The effort along the line of increasing vacuums had, as its basis, the desirability of decreasing T_2.

When further progress along this line was impractical, attention was centered on the increase of cycle efficiency through the increase of T_1. This led to the increasing use of high pressures and temperatures in power-plant practice. However, there are practical limits in this direction also, since the critical temperature of steam is about 706 deg. F. and its pressure is very high (about 3,200 lb. per sq.in.) at that temperature. Again the investigation in regard to binary processes was revived, and in 1913 the idea of the mercury-steam binary process was advanced. A semi-commercial installation of this character has been in operation at Hartford, Conn., since 1923.

The ideal fluid for the generation of power, from the practical viewpoint, should possess two cardinal properties. The saturation pressure should be moderate at high temperatures so that it may be easily handled. At low temperatures the pressures should not be so low as to cause enormous volumes of exhaust vapor.

The pressure-temperature relations of various fluids that may be used in power generation are represented in Fig. 1. The dotted line indicates the ideal vapor. No one existing fluid fulfills these requirements, and the binary process is, therefore, a means to approximate the ideal vapor by the use of two.

Carnot's expression for efficiency presupposes the absorption of heat at constant temperature. Actually, every fluid deviates from Carnot's requirement in that the heat of the liquid is absorbed at varying temperatures, although the latent heat of vaporization is added at constant temperature. It follows that the greater the ratio of the heat of vaporization to the specific heat of the liquid (or the steeper the liquid line on the temperature-entropy diagram), the more nearly does the liquid approach Carnot's requirement. Therefore it may be stated that the greater this ratio is found to be in a vapor, the better suited is that vapor thermodynamically for power generation.

Table I shows the value of the ratio of L to c for different vapors, where L is the heat of vaporization and c the specific heat of the liquid. The values of L and c for steam and mercury are taken from Mr. Kearton's article in *Engineering* for Nov. 23 and 30, 1923, those for ammonia and carbon dioxide from

Lucke's "Engineering Thermodynamics" and those for sulphur dioxide from Peabody's steam tables.

Low pressures and, consequently, large volumes at low temperatures involve many difficulties in handling

TABLE I—VALUES OF RATIO OF L to c FOR VARIOUS FLUIDS

Temp. Deg. F.	Mercury			Steam		
	L	c	Ratio	L	c	Ratio
32	132.97	0.0335	3,970	1,073.4	1.009	1,064
100	132.31	0.0332	3,990	1,035.6	.9967	1,040
200	131.34	0.0329	4,000	977.8	1.0039	973
300	130.37	0.0328	3,980	909.5	1.029	884
400	129.41	0.0327	3,940	827.2	1.064	777
500	128.44	0.0332	3,870	727	1.112	653
600	127.47	0.0335	3,810	585	1.172	500
700	126.58	0.0338	3,750			
800	125.94	0.0347	3,620			
900	125.29	0.0345	3,640			
	Ammonia			Sulphur Dioxide		
32	548.2	1.1	496	176	0.2	880
100	475.5	1.1	432	158	0.2	790
200	318	1.3	244			
	Carbon Dioxide					
32	372	2.11	176			

and present serious problems in steam-turbine design. Larger condensing equipment and expensive piping are necessitated and greater evacuation losses incurred.

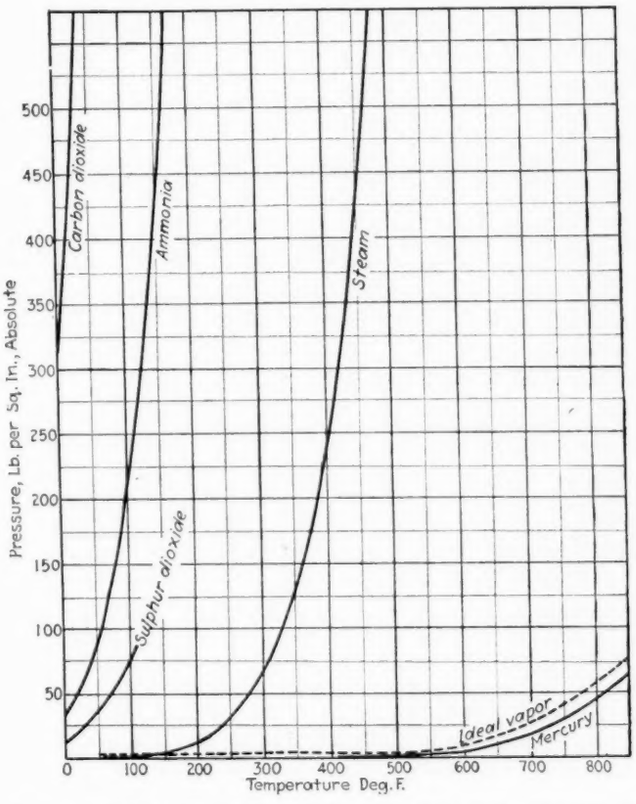


Fig. 1—Relation of temperature and saturation pressure for various vapors which may be used in power generation

Therefore the ideal vapor should have a reasonable volume at low temperatures. In addition, a fluid suitable for power purposes must, from the practical viewpoint, be easy to handle, not detrimental to the engine or turbine and of moderate cost. These practical qualities, and the thermodynamic requirements mentioned previously, furnish a basis for the comparison of the properties of the various fluids suggested for power generation.

Steam is the best known of the vapors used in power generation. Through long use its suitability for the generation of power has come to be accepted. Undoubtedly, all factors considered, it is the best single vapor that may be put to such use. Yet steam has decided and important drawbacks. Its critical temperature and pressure are 706 deg. F. and 3,200 lb. respectively, and the practical disadvantages surrounding the use of such a high pressure are very great. Steam cannot be used to any great advantage, theoretically, above 706 deg., since these temperatures can be reached only by superheating and this condition again implies the absorption of heat at varying temperatures. Steam therefore leaves much to be desired at the higher temperatures. However, at the lower temperatures its use is much more advantageous owing to the comparative steepness of its liquid line and to practical advantages such as its abundance in nature and its non-corrosive character.

Ammonia might prove an attractive fluid for power purposes if a means of cooling of exceptionally low temperature were available. Its pressure is well above atmosphere even at temperatures considerably below zero, and its specific volume is only a small fraction of that of steam. Its heat of vaporization is second to that of steam, and its critical temperature is 266 deg. F. at a corresponding pressure of 1,690 lb. Its pungent odor is an undesirable feature and its cheapness one that is in its favor. It might, conceivably, be used as a secondary fluid to steam at very low temperatures, temperatures that at present there is no practical means of attaining.

Sulphur dioxide has already been used in binary engines such as those invented by Professor Josse, of Germany, in the early years of this century. In Josse's engine it was employed for the temperature range from 100 deg., with a corresponding pressure of 85 lb., down to condensing temperature. At the ordinary condensing temperature of 70 deg. it has a pressure of 50 lb. At high temperatures its pressures are so excessive as to be out of the question, so that its use would be found as a secondary vapor for low temperatures only. It is low in price, but its heat of vaporization is low and it forms sulphurous acid in combination with water. This acid is decidedly detrimental to engine parts.

Carbon dioxide is definitely removed from consideration as a power medium by its low critical temperature and high pressures at even ordinary temperatures. For instance, its pressure at 70 deg. is 851 lb. Its critical temperature is 88.4 deg. at a pressure of 1,070 lb.

Ether, another fluid with which experiments have been made in connection with the development of a binary process, has a pressure of about 90 lb. at 212 deg., but at 60 deg. this pressure becomes less than atmospheric, necessitating the use of an air pump to maintain the vacuum. A serious objection to ether is found in its volatile and inflammable character. It is a general truth that, the more volatile a liquid, the smaller is its heat of vaporization. Volatile fluids, owing to their smaller capacity for heat absorption, may suffer a considerable loss in pressure through a small lowering of their temperature. The greater the pressure fluctuation, as compared to the temperature change, the more nearly is the vapor approaching its critical state.

Ether may, obviously, be considered only as a possibility for the secondary fluid in the binary process, to be used over the lower range of temperature, and its advantages in this respect are minimized by the fact

that, even at these low temperatures, it is very close to its critical condition, making it possible for a small change in the final temperature of the primary fluid to cause a large difference in the resulting ether pressure.

Advantages of Mercury for High Temperatures

Thus far only vapors that may be used for low temperatures and, therefore, for secondary vapors in binary processes, have been considered. For high temperatures mercury has undeniable advantages. At atmospheric pressure its saturation temperature is 677 deg., and at 70 lb. it is 884 deg. This combination of high temperature and moderate pressure is one of the most important factors favoring the choice of mercury for the high-temperature range. Another factor in its favor is the greater value of the ratio of latent heat to specific heat as shown in Table I and also in the slope of the liquid line in the small diagram to the left in Fig. 2, which represents the properties of mercury as referred to the temperature-entropy chart. Its vapor density is several times that of steam at the same temperature, so that a mercury turbine is much smaller than a steam turbine of equal capacity.

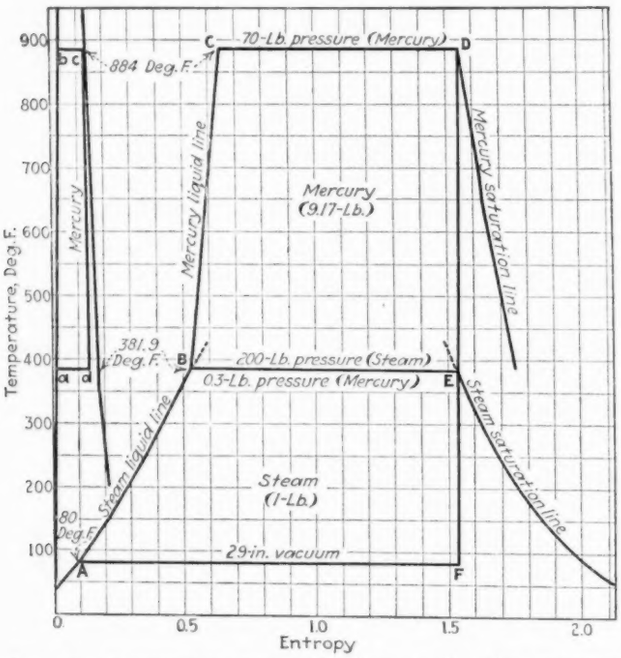


Fig. 2—Mercury-steam cycle for 70 lb. abs. mercury pressure, 200 lb. abs. steam pressure and 29-in. vacuum on steam-turbine exhaust

Cycle evaporates 9.17 lb. mercury per pound of steam. Small diagram at left is temperature-entropy diagram for one pound of mercury.

In short, in spite of its poisonous character and the care necessary as a consequence in design and operation to eliminate leakage, mercury offers distinct possibilities in the higher temperature ranges. Its cost averages about one dollar a pound, and the world production in 1921 was 4,451,000 lb., enough to supply only 148 boilers such as that installed at Hartford. However, it is probable that if the future should develop a greater demand for mercury, due to the success of a binary process employing it as one of the fluids, the annual production could be greatly increased and the unit cost could probably be materially reduced.

Other substances suggested for high temperatures are sulphur, diphenal, diphenal ether and benzophenone. The possibilities of all these substances have been investigated by Parkman Coffin, of the General Electric Research Laboratory. With the exception of sulphur none of them can stand constant boiling without deterioration. Sulphur is viscous, a poor conductor of heat and attacks steel at high temperatures.

It is evident that power fluids may be divided into two classes, those suited to power generation at low temperatures and those adapted for the same purpose at the higher range of temperature. Steam has some disadvantages as a fluid to be used at low temperatures, the chief of these being its comparatively large volume at low temperatures and that its pressure at temperatures commonly available in cooling water is less than atmospheric, necessitating the use of an air pump to maintain the vacuum. Modern practice in steam-turbine design has overcome some of the objectionable features of the first of these drawbacks; the second is a thermodynamic condition for which there is no remedy.

TABLE II—ANALYSIS OF CYCLE SHOWN IN FIG. 2

Temperature of saturated steam at 200 lb., deg. F.	381.9
Vapor pressure of mercury at 381.9 deg. F., lb. abs.	0.3
Heat content per lb. of mercury at 70 lb. pressure, B.t.u.	153
Heat content after adiabatic expansion to 0.3 lb. B.t.u.	104
Useful work performed per pound of mercury, B.t.u.	49
Heat of liquid per lb. of mercury at 381.9 deg., B.t.u.	12
Heat available for evaporation of steam per lb. mercury, B.t.u.	92
A—Feed water not heated after leaving condenser:	
Heat content per lb. of steam at 200 lb., B.t.u.	1,198.5
Heat of liquid per lb. at 29-in. vacuum, B.t.u.	47.1
Heat required to evaporate 1 lb. of steam, B.t.u.	1,151.4
Weight of mercury required per lb. of steam, lb.	12.5
B—Feed water heated to saturation temperature from an outside source:	
Heat content per lb. of steam at 200 lb., B.t.u.	1,198.5
Heat of the liquid per lb. at 381.9 deg., B.t.u.	354.5
Heat required to evaporate one lb. of steam, B.t.u.	844.0
Weight of mercury required per lb. of steam, lb.	9.17
(Since mercury is costly and the flue-gas temperature is high, the second method is to be preferred.)	
Summary of Useful Work	
Useful work available in 9.17 lb. of mercury, B.t.u.	449
Heat content of 1 lb. of steam after adiabatic expansion from 200 lb. to 29-in. vacuum, B.t.u.	831
Useful work available per lb. of steam (1,198.5—831), B.t.u.	367.5
Total heat available for useful work (449 plus 367.5), B.t.u.	816.5
Summary of Heat Added	
Heat added to 9.17 lb. of mercury (9.17 x (153-12)), B.t.u.	1,293
Heat added to the feed water (354.5-47.1), B.t.u.	307.4
Total heat added, B.t.u.	1,600.4
Efficiency 816.5 ÷ 1,600.4, per cent	51.0

On the other hand, steam, because of its many practical advantages, has made it doubtful whether any other secondary fluid will ever be used again. A gain in temperature range of only a few degrees or a reduction in turbine size might be possible by the use of another fluid, but this advantage would be more than offset by the increased cost, complication and uncertainty of operation. In the field of high temperatures, if we except steam, mercury seems to be the logical choice on account of the advantages previously detailed. In the choice of two liquids to be used in a binary process, the preference, among those so far considered, probably rests with mercury and steam.

To illustrate more fully the thermodynamic advantage of the use of mercury and steam in such a process, a detailed analysis is given in Table II. In this analysis the mercury is assumed to be evaporated at a pressure of 70 lb. absolute, the steam at 200 lb. absolute, and the exhaust pressure of the steam is assumed to be equivalent to a 29-in. vacuum. These are approximately the conditions under which the new Hartford installation operates. The cycle is represented in Fig. 2. The

area *BCDE* indicates graphically the work done by the mercury, the axis having been shifted and the liquid and saturation values multiplied by a coefficient (9.17) so that the heat of the mercury vapor at its exhaust pressure is equal to the heat required to evaporate one pound of steam at 200 lb.

Combining the cycle efficiency of 51 per cent given in the last line of Table II with a turbine efficiency of 70 per cent and a boiler efficiency of 85 per cent, a kilowatt-hour could be generated from 11,200 B.t.u.

It is of interest to note that the steam-reheating cycle, based upon an initial pressure of 550 lb. and an initial temperature of 750 deg., expanding adiabatically to the saturated condition, reheating to the initial temperature and then exhausting to a 29-in. vacuum, consumes practically the same number of heat units in completing the cycle and has a maximum calculated efficiency of only 40.6 per cent.

In conclusion, it may be predicted that, in the future, the upward extension of temperatures will open a new field of power development, and it seems possible that some adaptation of the binary process may be the means of attaining these high temperatures safely and conveniently. Whether this system is eventually a commercial success will depend largely upon the results achieved from the present installations.

Stunts with the Welding Torch

By L. A. Cowles*

The welding torch may be used to caseharden. The steel is brought up to a white heat, the oxygen shut off and the acetylene played on the metal. Repeating this process adds carbon, and a thin, hard surface is the result.

Welding upside down is quite feasible, although many think that the piece to be welded must be in such a position that the weld is made down. In welding around a pipe, it is necessary to weld up. With a little practice it will be found that this is not at all difficult. In welding pipe, start at the bottom center and weld around to the top center. Then repeat on the opposite side. On large pieces two or more welders work simultaneously to minimize contraction strains.

When welding thin spots in boiler tubes and pipe, a hole through the metal often will burn through, and the welder, in attempting to close it, may find he is only making it larger. To remedy this, stick one end of the filler rod to one side of the hole. Lift the torch and then stick the filler rod to the opposite side. Keep bridging across with the filler rod until it is possible to go back over and weld the bridge and sides together, working toward the center and adding metal as needed. In this way large gaps or holes can be closed up.

A hole can be drilled in concrete by heating with the welding torch. No great depth can be drilled because of the torch tip heating. The concrete pops, explodes and flakes off. The success of an attempt to drill concrete depends upon the moisture content of the concrete. Do not use a concrete floor to weld on, for if the heat from the torch strikes the floor, it will flake off.

When some part is broken and the piece is missing, it may be necessary to cut out and weld on a piece from some old casting. Often the missing part can be built up with filler rod of about the right size and shape to take its place.

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To cool a bearing, deep grooves were cut in the lining, copper tubing was placed in the grooves and the torch used to run in babbitt metal over the tubes and to fill the grooves. The bearing was then scraped in and the tubing connected to the water supply. The result was a cool bearing that previously had given endless trouble.

A pit developed in the slip ring on a generator. The cable lead was clamped to the generator shaft and for three days the shaft was used as a collector ring. When the unit could be shut down for several days, the pit was filled by welding and turned down in place. This repair saved the cost of a new slip ring, and as it was not removed for making the repair, the time saved paid for the materials used.

Saving an old exhaust head was easy in the following case: Installing a uniflow engine and a turbine made it necessary to increase the size of the exhaust line. Of course this called for a new exhaust head unless the old one could be made larger. This was done by cutting it lengthwise, spreading it apart and welding in a strip of sheet iron, thereby making the old head two sizes larger.

Fifteen short pieces of ½-in. guy cable had been thrown away as too short to use or splice. By using a small tip these pieces were all welded together, making 40 ft. of perfectly good cable.

A hot-water tank in the basement of one of the buildings had rusted through at the point where the steam coil entered the end of the tank. The thin section was cut out and a piece welded in. This saved the cost of two new tanks and their installation, for the building must have been built around the tank, as there was no room to get out or in with one of the same size and it would have been necessary to replace it with two of half size.

Repairing bags and blisters in boiler tubes saves much time and expense. In the case of a large bag in a tube, it is the writer's practice to cut a hole through the center of the bag, heat and hammer the bag up to shape and weld up the hole. Small blisters are heated and hammered up. We have never had a repair made to a tube give any trouble or come down again. A ruptured tube can be repaired by welding, but if the rupture is long and difficult to get at, a new tube is the cheaper.

In cutting out tubes there is usually little space for the head of the cutting torch and it is difficult to see to cut the upper two or three inches of tube. The better way is to cut out a section, then cut from the inside out. This removes enough of the tube so that it can be driven and the ends pulled so as to miss each other. If there is any scale, it will have to be cleaned off in line with the cut, when cutting from the inside. If the baffles are left on the tubes, some support should be put in for the long ends, as the weight of the baffles may bring them down on the welder. The cost in time and material (gases) for eleven tubes was one-half hour and $1.70. The time saved was six hours cutting with a mechanical tube cutter, and twelve hours for two men removing and replacing brickwork not necessary when the torch was used.

Specific gravity of a solid or liquid, abbreviated sp.gr., is the name given to the number obtained by dividing the weight of a given volume of that substance by the weight of the same volume of distilled water at a temperature of 39.2 deg. Fahrenheit.

Boiler Feed-Water Purification—1

Natural Waters and Their Impurities

By SHEPPARD T. POWELL
Consulting Chemical Engineer, Baltimore, Md.

THE prevention of corrosion or scale in boilers by proper methods of feed-water purification is a matter of dollars-and-cents importance to every operating engineer. Yet, strange to say, no comprehensive up-to-date survey of this subject is available either in books or in the files of technical journals. The present series, which will be published later in book form, is designed to meet this need. Mr. Powell is prepared to give the power-plant reader the kind of practical, unbiased information that will help him solve the every-day problems of boiler operation. This introductory article tells what impurities are found in natural waters, how they get there and what troubles they lead to in boiler operation. Later articles will take up the practical details of purification by all of the established methods.

WATER is a tasteless, colorless, and odorless liquid. It is a chemical compound expressed by the formula H_2O, indicating the combination of two volumes of hydrogen and one of oxygen. Chemically pure water is an extremely rare article and difficult to obtain, since practically all substances are soluble to some degree in it. Because of this property water is readily contaminated by substances with which it comes in contact.

The primary source of water is the oceans, and all water eventually returns to these reservoirs. The cycle that water makes in the universe is similar to that of a huge distilling apparatus. Owing to the heat of the sun vapors are passed upward from the water surfaces of the earth, eventually forming clouds. These moisture-ladened atmospheres, when brought into contact with the colder air currents, are condensed and rain or snow results.

From the time water reaches the vapor stage until it is finally discharged again into the ocean, contamination is going on (see Fig. 1). The character of the contamination depends upon the territory over which the clouds form and where the rain or snow is precipitated. Rain water collected in rural districts, remote from the seaboard or at distances from industrial centers, contains but a small amount of salts, gases, acids or dust particles. The amount of these substances in rain water caught near the oceans or in or near cities, is frequently relatively great.[1]

Of the water that falls on the earth's surface approximately one-third flows back to the ocean by means of surface water courses, while twice this volume is evaporated or sinks into the ground, to reappear as springs and wells, or reach the ocean eventually by subterranean streams. Rain thus coming into contact with minerals and metals in the earth, dissolves these materials. The solvent action of water upon mineral substances is increased greatly by the presence of gases of various composition dissolved in the water.

The most important gases contained in water are carbon-dioxide (CO_2) and oxygen (O_2). The atmosphere contains 0.04 per cent of carbon-dioxide gas, and since this gas goes into solution readily in water, an appreciable amount of it is taken up as the rain falls to the earth. The carbon-dioxide content of water may be, and frequently is, increased by decomposing organic matter and by industrial wastes. The relatively weak solution of carbonic acid in rain water, in addition to the dissolved oxygen and other constituents, gradually dissolves the earth's crust. As a result of these conditions water, as obtained from rivers, lakes, springs or other sources, is not merely a simple chemical compound consisting of hydrogen and oxygen, but a complex solution containing many organic and inorganic substances.

The chemical composition of water reflects to a great extent the character of the geological territory from which it is obtained. Hard water is obtained from territory where limestone or gypsum is abundant, alkaline water where alkaline deposits occur, and so on through a large list of mineral or metallic substances. In addition to the constituents that go into solution in water, many surface streams carry along much matter in suspension due to erosion of the watersheds or to the discharge of trade wastes into the surface water courses. All these conditions have a marked deteriorating effect upon the quality of water for use in boilers to make steam.

TABLE I—AVERAGE ANALYSIS OF RAINWATER 25 MILES FROM LONDON

	Parts per Million
Organic carbon	0.99
Organic nitrogen	0.22
Ammonia	0.50
Nitrogen as nitrates and nitrites	0.07
Chlorine	6.30
Total solids	39.50

A perfect water for boiler-feed use is one that will not deposit any scale-forming substances, will not corrode metal of boilers or appurtenances and will result in neither priming nor foaming. This quality of water is seldom obtainable except by artificial purification

[1] Rain water collected twenty-five miles from London is reported as giving (for an average of seventy-three samples) the analytical results shown in Table I. (Refer to Dr. William P. Mason, Water Supply, page 219, 3rd Edition, 1905.) During a year an enormous amount of solid material will be deposited with rain, as may be noted from the results of analyses reported in Table II and Fig. 2.

whereby the impurities that may cause scale or corrosion are removed or changed to less objectionable forms.

Although a great variety of mineral salts or acids may be present in natural waters, there are a relatively small number of these constituents which are to be found in sufficient amounts to be troublesome. In Table III is given a list of the constituents present at times in some waters, which may be objectionable when present in boiler-feed water.

TABLE II—ANALYSIS OF RELATIVELY PURE RAIN WATER*

	Parts per 1,000,000	Grains per U. S. Gal.†	Lb. per Inch of Rain per Acre†
Insoluble Matter:			
Tar	0.41	0.024	0.093
Carbonaceous (other than tar)	8.0	0.466	1.807
Ash	16.0	0.932	3.614
Soluble Matter:			
Loss on ignition	6.0	0.349	1.360
Ash	12.1	0.705	2.734
Total solids	41.0	2.39	9.271
Included in soluble matter:			
Sulphuric as SO_4	8.0	0.466	1.807
Chlorine as Cl	2.5	0.145	0.563
Ammonia as NH_3	0.41	0.024	0.093

* After Sir Alexander Houston
† Calculated by the author.

The deposition of solids within boilers under steaming conditions results in an accumulation of sludge or mud or the production of stone-like deposits known as scale (see Fig. 3). These deposits, whether in the form of scale or mud, are highly objectionable since they are poor conductors of heat, cause reduced efficiency, and are frequently responsible for burnt tubes or plates.

The mechanism of scale formation is somewhat complex and has been the subject of much discussion of a controversial nature for many years past. The resulting scale from the deposition of mineral constituents in boilers does not consist of a single salt; it is composed of a number of elements combined in forms frequently much unlike the salts originally present in the feed water. This state of matter is the natural sequence of physical and chemical phenomena resulting from the reactions at high temperatures and pressures existing in steam boilers. Chemists and engineers have developed certain theories concerning the matter in order to explain scale formation and to develop operating methods and treatments either for controlling or inhibiting them.

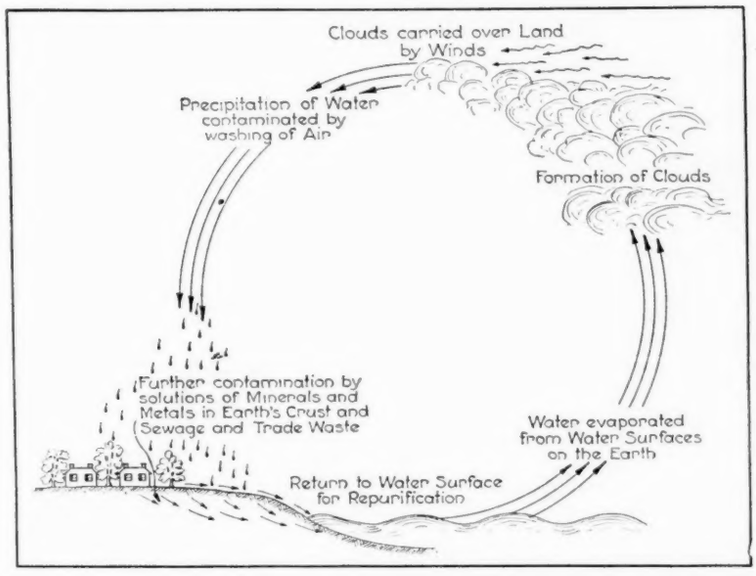

Clouds carried over Land by Winds
Precipitation of Water contaminated by washing of Air
Formation of Clouds
Further contamination by solutions of Minerals and Metals in Earth's Crust and Sewage and Trade Waste
Water evaporated from Water Surfaces on the Earth
Return to Water Surface for Repurification

Fig. 1 (Left)—Nature's distillation cycle is in ceaseless operation

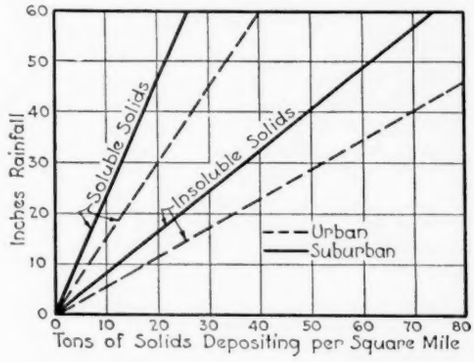


Fig. 2 (Above)—Estimated tons of solids deposited per square mile in an urban territory (Baltimore City) and in a suburban district (8 miles from Baltimore City)

The economic losses resulting from scale formation in stationary and locomotive boilers have been and still

TABLE III—COMMON IMPURITIES IN WATER AND THE POSSIBLE EFFECT WHEN USED FOR BOILER-FEED PURPOSES

Constituent	Chemical Formula	Principal Source of Contaminating Substance	Possible Effect When Present in Boiler Waters	Treatment for Removal from Water
Suspended solids	.....	Surface drainage, trade waste	Priming, foaming, sludge or scale	Plain subsidence, coagulation, filtration, evaporators
Silica	SiO_2	Mineral deposits	Scale	Plain subsidence, coagulation, filtration, evaporators
Calcium carbonate	$CaCO_3$	Mineral deposits	Scale	Softening by chemical, by base-exchange material, evaporators
Calcium-bicarbonate	$Ca(HCO_3)_2$	Mineral deposits	Scale	Softening by heaters, by chemical or by base-exchange material, evaporators
Calcium sulphate	$CaSO_4$ $CaSO_4=2H_2O$	Mineral deposits	Scale, corrosion	Softening by chemical or by base-exchange materials, by evaporators
Calcium chloride	$CaCl_2$	Mineral deposits	Scale	Softening by chemical or by base-exchange material, evaporators
Magnesium carbonate	$MgCO_3$	Mineral deposits	Scale	Softening by chemical or by base-exchange materials, by evaporators
Magnesium bicarbonate	$Mg(HCO_3)_2$	Mineral deposits	Scale	Softening by chemical or by base-exchange materials, by evaporators
Magnesium chloride	$MgCl_2$	Mineral deposits	Scale, corrosion	Softening by chemical or by base-exchange materials, by evaporators
Free acids	HCl, H_2SO_4	Mine drainage, trade waste	Corrosion	Neutralizing acid, followed at times by softening or evaporation
Sodium chloride	NaCl	Sewage, trade waste, mineral deposits	Inert but may be corrosive under some conditions	Evaporator
Sodium carbonate	Na_2CO_3	Mineral deposits	Priming and foaming, embrittlement	Evaporator
Sodium bicarbonate	$NaHCO_3$	Mineral deposits	Priming and foaming, embrittlement	Evaporator
Carbonic acid	H_2CO_3	Absorption from the atmosphere, mineral deposits, decomposition of organic matter	Corrosion	Deaerator
Oxygen	O_2	Absorption from the atmosphere	Corrosion	Deaerator
Grease and oil	.....	Trade waste	Corrosion, deposits, priming, foaming	Coagulation, filter, evaporator
Organic matter and sewage	.....	Domestic and trade wastes	Corrosion, deposits, priming, foaming	Coagulation, filter, evaporator

are enormous. The conduction of heat by scale is relatively low and results, therefore, in reduced boiler efficiency. Much material has been published relating to fuel losses from scale. Many of the early investigators' results are misleading, however, since their conclusions have been based upon insufficient and unreliable data. The heat-insulating properties of scale may not be measured in terms of thickness only. This fact is stated tersely by Prof. S. W. Parr in summarizing as follows the results of the studies made by Professor Schmidt, at the University of Illinois:

1. Considering scale of ordinary thickness, say of thickness up to ¼ in., the loss in heat transmission due to scale may vary in individual cases from insignificant amounts to as much as 10 or 12 per cent.
2. The loss increases somewhat with the thickness of the scale.
3. The mechanical structure of the scale is of as much or more importance as the thickness in producing this loss.

Some investigators have attempted to classify scale as being either hard or soft, and by so doing to predicate the loss of energy resulting therefrom. This classification is a difficult one, since hardness is a relative term and is therefore indefinite. The hardness of a scale depends primarily upon the condition resulting in the deposition of the hardening salt, and this in turn involves the chemical phenomena of solubility at given temperatures and pressure. Since scale is generally the result of the deposition of a number of salts, the density of the structure is influenced by the reaction of one salt with another. As a rule, dense adherent scale results from the use of untreated boiler-feed water

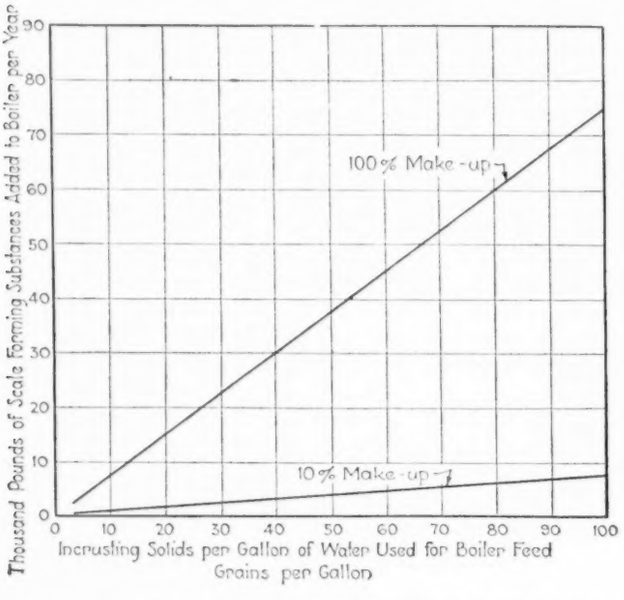

Thousand Pounds of Scale Forming Substances Added to Boiler per Year
100% Make-up
10% Make-up
Incrusting Solids per Gallon of Water Used for Boiler Feed
Grains per Gallon

Fig. 3—Scale-forming solids deposited yearly in a 2,000-sq.ft. boiler operating at rating 24 hr. per day, 300 days per year

containing calcium sulphate, certain forms of silicates, or carbonates and silicates. Water containing carbonate or bicarbonate hardness results in the formation of a relatively softer scale. These conditions, however, as has been indicated, will be materially influenced by many other factors.

An interesting study on "The Influence of Scale on the Efficiency and Safety of Heat Appliances" was made at the Bavarian Research Society by Dr. E. Reutlinger. Three series of tests were conducted with scale of different thickness and composition:

1. A hard dense scale 1.4 mm. thick obtained by evaporating a calcium sulphate water.
2. A scale 5.5 mm. in thickness of much the same composition.

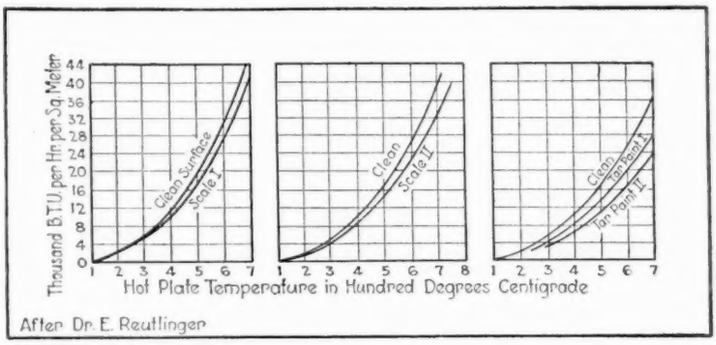


Fig. 4—Dr. Reutlinger's experiments showing the effect of deposits on heat transmission through boiler tubes (see text)

3. Tar paint 0.3 mm. in thickness.

The insulating properties of these three deposits were determined. The results are reported graphically in Fig. 4. These graphs are of considerable interest, since they demonstrate not only the relatively high insulation properties of scale, but also that of tarry substances which at times may contaminate feed-water sources. Any scale formed in boilers results in reduced operating efficiency.

The composition of scale varies greatly with different water supplies and it is difficult to predict with any degree of accuracy the specific characteristic of the deposits from similar or even the same water source under different steaming conditions. The density and texture of the deposits are influenced greatly by boiler operating conditions. This fact is illustrated by Table IV, which gives analyses of scale taken from boilers

TABLE IV.—SAMPLES OF SCALE DEPOSITED FROM THE SAME WATER SUPPLY

	No. 1	No. 2
Silica (SiO_2)	2.12	3.64
Iron and aluminum oxides (Al_2O_3 and Fe_2O_3)	0.11	1.21
Calcium carbonate	85.31	68.00
Calcium hydrate	1.26	0.98
Calcium sulphate	9.86	25.20
Magnesium hydrate	0.15	0.90
Undetermined	1.19	0.07
Total	100.00	100.00

TABLE V—TWO SAMPLES OF SCALE DEPOSITED IN THE SAME BOILER

	Scale from Front of Boiler	Scale from Back of Boiler
Silica	2.28	7.08
Oxide of iron	2.00	5.52
Sulphate of lime	75.38	30.63
Carbonate of lime	13.28	41.55
Magnesium hydrate	6.09	10.64
Organic matter, etc.	0.97	4.58
	100.00	100.00

using the same raw-water supply. Both plants function practically the same with respect to load and percentage of makeup water. Scale No. 1 was taken from a boiler that is blown down at frequent stated periods. Scale No. 2 was from a plant where control in this respect is haphazard and lax. Both samples were from the first row of tubes.

An even more pronounced change in the composition of boiler scale is shown by Paul. Table V gives his analyses of scale deposited at the front and at the back of the same boiler.

The major losses due to scale may be summed up briefly as follows:

1. Reduced efficiency due to insulating properties of the scale.
2. Economic loss due to boiler outages during cleaning periods.
3. Increased maintenance as a result of internal cleaning.
4. Depreciation of equipment occurring from scale formation and removal.

It is difficult to evaluate the effect of scale in boilers since there are many factors to be considered in establishing the specific losses in efficiency attributable to this cause. That scale does cause such losses requires no argument. Many writers, however, in their enthusiasm to present the subject forcibly have exaggerated these losses. Scale is frequently held responsible for reduced boiler efficiency for which many other defects in operation are responsible.

The history of boiler-water purification indicates that many methods of treatment have been developed for conditioning water for use in steam boilers. It would be of little value to attempt to enumerate all the various special types of apparatus that have been designed or placed on the market for this purpose. Probably all appliances that have been used with success may be classified under one or more of the following headings, at least as far as basic principles are concerned:

(a) Plain sedimentation
(b) Sedimentation aided by chemicals
(c) Filtration
(d) Softening by chemicals
(e) Softening by base-exchange materials
(f) Evaporation
(g) Internal treatment (boiler compounds)
(h) Deconcentration
(i) Deaëration
(j) Miscellaneous methods: Electrolytic treatment, continuous blow-down, heaters, etc.

(To be continued)

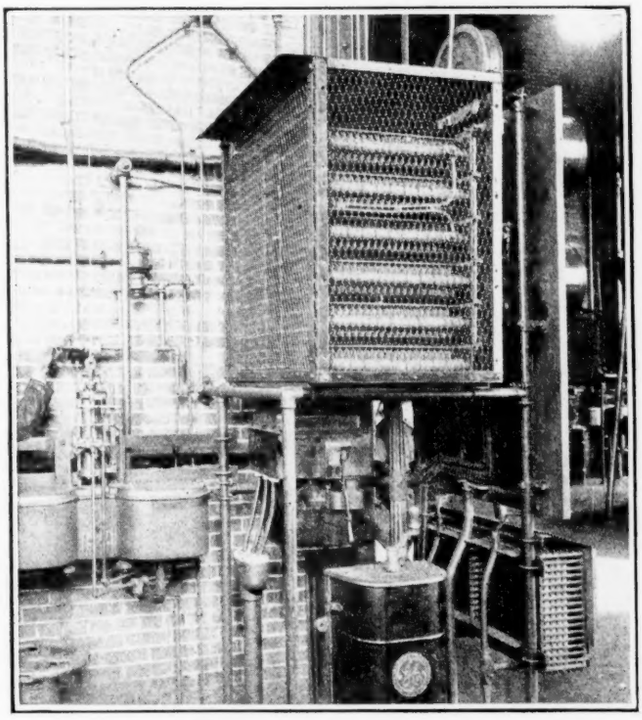
Continuous 12 per Cent CO_2 in a Central Heating Plant

An engineer who says, "This one improvement made our plant 6½ per cent more efficient," frequently forgets that the improvement he refers to perhaps necessitated a close check-up on various other items or was merely the starting point of other changes, the aggregate of which resulted in the 6½ per cent increase in efficiency. That the large increase in efficiency and savings effected is the summation of several improvements and not the result of one particular change, was undoubtedly true in the case of the central-heating plant of the Georgia Railway & Power Co. at Atlanta, which was rebuilt some time ago and made into a plant for furnishing steam to a number of office buildings, hotels, loft buildings, etc.

A new boiler house was built and four old 6,000-sq.ft. water-tube boilers were raised on high settings and equipped with new stokers. Both forced and induced draft were installed, and the boilers are run at about 220 per cent of rating.

But the mere knowledge that a plant can be keyed up to extremely economical operation means nothing unless the efficiency is maintained high over a considerable period. Adequate indicating and recording meters were therefore installed as an assurance that conditions will be constantly watched. At each boiler an instrument board is installed, on which are mounted all the meters and instruments showing the operation of that boiler. On each board is a recorder which records the CO_2 content and the flue-gas temperature. Besides this there is a flow meter, pressure and draft indicator, etc. At the bottom of the board are the controls for the fan, damper and stoker motors. With this arrangement the fireman can observe the operation of the boiler and immediately correct any condition that is not right.

The CO_2-flue-gas temperature recorder operates electrically and gives the fireman a continuous record of the



Instrument board and motor controls at each boiler

flue-gas content and shows any change almost immediately, both these factors being recorded on one chart.

With the boilers operating at 200 per cent rating and the flue gas at 525 deg., an average CO_2 of about 12 per cent is maintained. Under the old conditions before the plant was changed, approximately 8 per cent CO_2 was the usual average.

Some interesting figures on central heating are contained in the recent report of the Committee on Operating Statistics of the National District Heating Association. On the basis of thirty-four companies reporting, the income per 1,000 lb. of steam varied from 35 cents to $1.43 with an average of 82.6 cents. The average evaporation was 6.65 lb. with 12,600 B.t.u. coal costing $4.18 per ton. Losses due to steam leaks, line losses, auxiliaries, traps, etc., varied from a minimum of 2.1 per cent to a maximum of 40.3 per cent, or an average of 19.3 per cent. Incidentally, this last figure is comparable with electric distribution losses in some large cities.

How to Lay Out Power-Plant Piping—IV*

By SABIN CROCKER
Designing Engineer, Drafting and Surveying Bureau, The Detroit Edison Company

DRIPS, bypasses, guard valves and similar matters are covered in this article. The next article of the series will discuss piping expansion and the proper location of spring and rigid hangers.

WITH the general scheme sketched out, with pipe sizes and materials selected, and with flange and fitting standards chosen, final drawings of the layout should be prepared. These may be simple or elaborate, depending upon circumstances. For

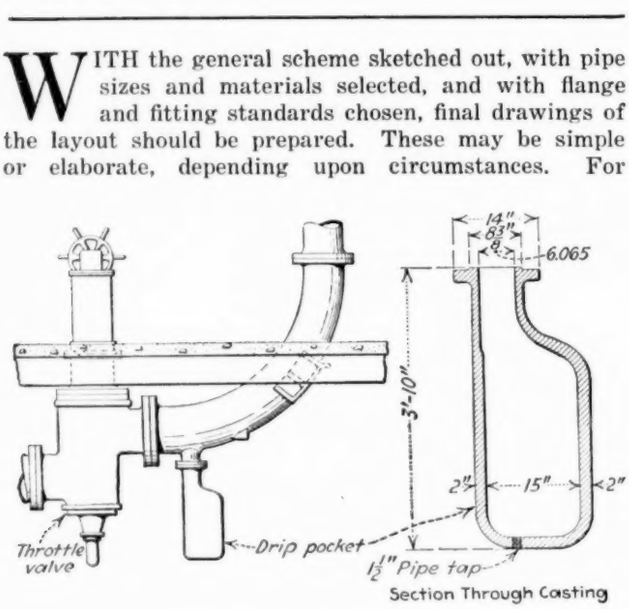


Fig. 1—Drip receiver at throttle valve of 50,000-kw. turbine, designed for steam at 375 lb. gage and 700 deg. F.

small pipe and for work that is not crowded, it may be sufficient to add a few notes to the original sketch and leave the details to the pipefitter foreman who does the job. For large work, requiring heavy shop fabrication of bends, Van Stone joints, etc., complete and accurate drawings are indispensable. A proper balance between drafting and field work has an important bearing on the cost of a job, but is largely a matter of judgment based on long experience.

However the actual details are worked out, on paper or in the field, there are a number of things that must be properly cared for if the system is to operate successfully.

Drips and Drip Systems

Steam lines must be properly pitched and dripped between valves and in pockets of the line in order to get rid of accumlations of water. Although there is no considerable amount of water to drip from a superheated steam line while it is in operation with a flow of steam through it, yet it is just as necessary that such provision be made here as in the case of a saturated steam line. Superheated lines with a valve closed at one end and no flow must be dripped, and during the period of warming up any line after a shutdown, large amounts of condensation have to be removed. It has been the author's observation that it is impossible to maintain superheat at the remote end of a long line under full pressure unless there is considerable steam flow through the line. In cases where an attempt is made to keep such a line warm by allowing steam to escape from a small bleeder valve at the far end, the temperature of the steam in the line will soon fall to the saturation point. The absence of superheat is, of course, obvious during the warming up of a line from a cold or semi-cold condition.

Where a line can be dripped at large manifold fittings in which the steam velocity is slowed down below that

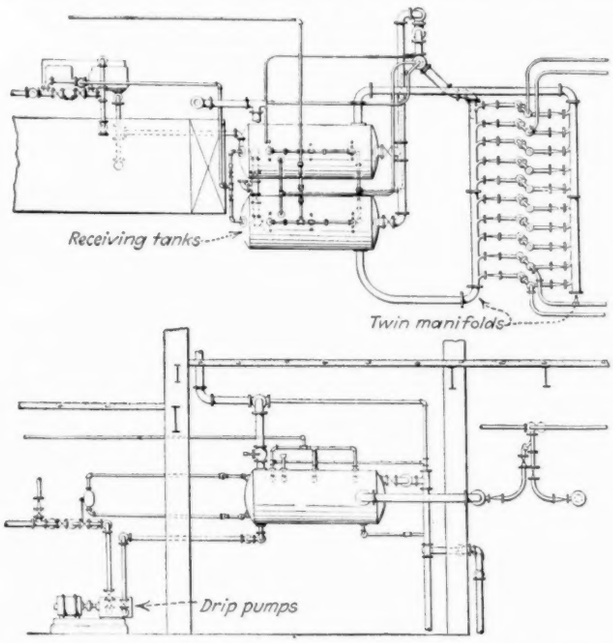


Fig. 2—Layout of drip piping at receiver tanks shows duplication to provide uninterrupted operation

in the pipe proper, it is good practice to dispense with the use of separators and save the attendant pressure drop. In the case of a steam line approaching a turbine from above, it is desirable to provide an adequate drip receiver close to the throttle. Such a receiver for a 50,000-kw. turbine is illustrated in Fig. 11. In the case of the large manifold illustrated in Fig. 3 of Part III (*Power* for June 15, 1926), a 1½-in. tapped drip connection appears coming tangentially off the bottom at mid-length of the casting.

In steam lines a liberal pitch should be given toward

*Part I in *Power* for May 18, 1926; Part II, June 8; and Part III, June 22.

drainage points. With long lines subject to considerable expansion both horizontally and vertically, the position of the line in both the hot and cold positions should be determined, and the pitch made sufficient to look after both. Important lines should be leveled up with surveyor's instruments during erection to insure that the calculated pitch is actually obtained. A minimum pitch of one inch in from 20 to 40 ft., gives adequate drainage.

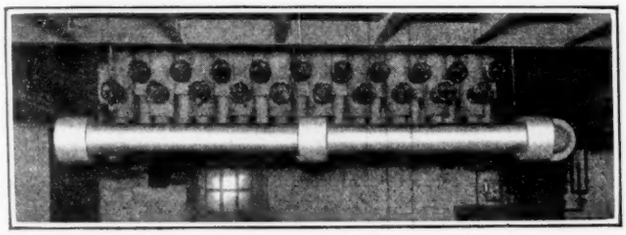
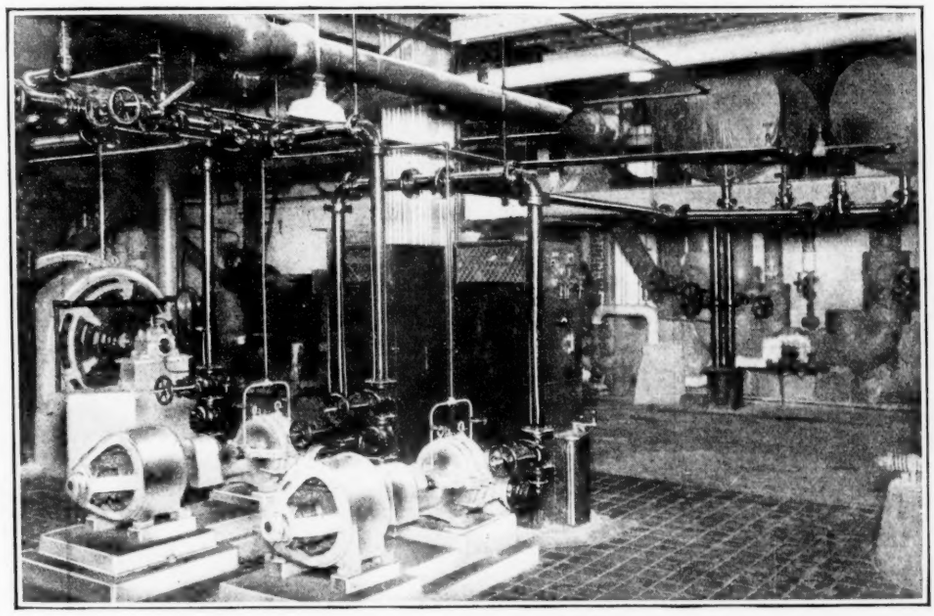


Fig. 3—The twin manifold valves are easily accessible and the simple arrangement avoids confusion

A good way of returning all the plant drips to the boiler-feed system is to provide a large receiving tank vented to atmosphere through a back-pressure valve, into which all the drips discharge. The temperature in this tank can be kept down, if necessary, by spraying in cool water from a hotwell pump discharge line. The accumulation of water in the receiving tank is removed by a float-controlled pump discharging to the boiler-feed hot tanks. The importance of this service usually requires that the receiving tanks and pumps be installed in duplicate. Figs. 2, 3 and 4 show such an installation in the Trenton Channel plant of The Detroit Edison Company.

Fig. 4—The hot drip tanks in the upper right corner are kept empty by the drip pumps below and at the left. Duplication safeguards the service. Just below the drip tanks is a special manifold for auxiliary steam distribution



Bypass Valves

With pressures above 300 lb., it is advisable to put bypasses around all valves 6-in. and larger on both steam and water lines, the obvious reason being that it is much easier to open the main valve with pressure equalized on both sides.

In many cases a bypass built up with pipe and fittings with two bypass valves is superior to a bypass with a single valve built into or on the main valve.

If a bypass valve leaks in a position where the line on one side of the main valve can be shut down, it is possible to repair the dual bypass valves one at a time. With a single bypass valve the line must be shut down on both sides of the main valve in order to effect a repair.

Guard Valves

It is good practice, where a valve is subject to severe cutting action, to install a guard valve in conjunction with it for tightness in shutting off the line. An example of this kind is the use of two valves in boiler blowoff lines, where the valve nearest the boiler is opened and closed only while the outer one is shut. In this way the outer valve is the only one subject to the erosion incidental to opening and closing under flow, and the valve next to the boiler is kept in the best condition possible for tight shutoff.

Another example is the use of a globe valve for throttling in a bypass, with a gate valve on each side of the globe for tight shutoff and to provide a convenient means of isolating the globe valve for repairs without shutting down the rest of the line. This arrangement is illustrated in Fig. 5, which shows a pressure-reducing station with a bypass around the reducing valve. The gates on each side of the reducing and globe valves make it possible to replace or repair either of these valves while the line is in operation.

It might be well to mention incidentally that filler pieces should always be provided between a reducing valve and the adjacent gates, as reducing valves are usually so constructed that it is impossible to remove all the end flange bolts when they are bolted directly to other valves or fittings due to close clearance at the valve bonnets or fitting necks. For convenience in removing these valves from the line, it is desirable to use flanged connections at such points even though the rest of the line is made up with screwed joints.

Another point worth mention is that when reducing from a pressure that requires the use of a heavy stand-

ard for flanges and fittings to a pressure with which a lighter standard is used, a relief valve should be provided on the low-pressure side. The use of the heavier standard should be continued through to the last valve ahead of the relief valve, as it is possible to have the full pressure up to that point.

Selection of Valves

The selection of the proper valve for any particular purpose depends, first, on the operating pressure and temperature, and second, on the type of valve best suited for the use to which it will be put. In some case where

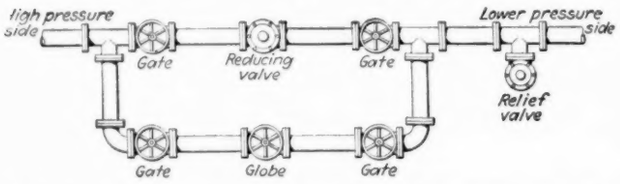


Fig. 5—Double guard valves make it possible to repair the reducing valve or hand throttle without shutting off the low-pressure steam service

either a globe or gate valve would serve equally well, the decision between these types may be based on price considerations.

In general, it is customary to use gate valves in locations where pressure drop through the valve is a consideration and where the valve will either be wide open or entirely closed. Guard valves and shutoffs for boiler and turbine leads, etc., are almost always of the gate type. Globe valves are seldom used in water lines because of the large friction losses involved with water flow through such valves. Globe valves are commonly used in steam and air lines for throttling purposes, as the globe type permits a closer regulation of flow. Throttling usually involves more or less cutting of the seat and disk, and these parts in globe valves are less expensive and more easily replaced than in gates. Among such uses for globe valves might be mentioned turbine and engine throttles, bypasses around traps or reducing valves, etc.

With reducing valves it is desirable to select a size that is loaded somewhere near capacity under normal operation, as such valves are then more stable in their operation. If there is a considerable seasonal variation in the load on a reducing valve, as in furnishing steam for building heating, it is good practice to install a large and a small valve in parallel and use the one best adapted to the load at any particular time.

Where more than one safety or relief valve is used on a boiler or other apparatus, it is desirable to set one or more of the valves to relieve at a lower pressure than the rest. This serves as a warning before too much steam is lost through all the valves opening at once, and also tends to facilitate repairs by confining any cutting action to the one or more valves that open first. In some cases an extra safety valve is set to blow before the others and is mounted above a gate valve, so that it can be removed and repaired while the boiler or steam line is in service. Of course the capacity of this valve cannot be considered in meeting the code or other legal requirements, for it might be shut off.

It is always advisable to use check valves in individual pump discharges before they join a common header. Check valves should always be provided close to where boiler-feed connections enter the drums, and where different lines are joined together to discharge into a common header, as in the case of a general service and a city water line each tied into the same fire protection header. It should be borne in mind that a check valve cannot be counted on for closing a line off tightly against pressure working back through, but it will stop any considerable flow. Where a city water line is connected through checks to another system under pressure, two valves with an open drip between should be provided in the city water line to prevent contaminated water from working through. In pump discharges where the header remains under pressure after the pump is shut down, a gate valve should be provided in addition to the check. It is also desirable to provide a small relief valve on the pump suction to prevent pressure backing up through the pump and damaging the foot valve while the pump is shut down.

Hydraulic Turbine Failed To Develop Rated Capacity

By M. B. Thurston

It is one thing to design a hydraulic turbine, it is another to sell it, and still another to set it up and put it in operation so that the customer will be satisfied and gladly write out his check for the balance of the contract payment.

One job I have in mind, where we were surely puzzled, was a large hydro-electric plant in the East. There are two units, each rated at 10,000 kw. and it was one of the finest jobs turned out by our factory at that time. The river was at normal head and everything seemed favorable for starting the units. The Mayor of the city touched a button, the gate valve opened up and the turbine started. In a few minutes it was put on the line and the officials left shortly after to enjoy a banquet.

Several old stand-by units were shut down to let the new machines take the full load, and then I started taking readings on the switchboard instruments. The company's chief operator accompanied me, and as soon as the readings were taken, we started figuring the power. Our slide rules told the same story and we put them down, staring at each other. Exactly two-thirds of the contract power was accounted for. We checked the head, made an approximate weir reading, which made the efficiency of the turbines so low as to be out of all reason.

As the units were both operating so smoothly and handling all the load, it was decided to let them run for awhile until we had a chance to go over the whole system and see what was wrong. The problem was not solved, and a preliminary test was due within a week, in accordance with the contract. One day while looking around the switchboard, with the generator builder's expert, we discovered that instrument transformers of the wrong ratio had been installed. Readings taken after the correct transformers had been installed showed the units to meet their guaranteed capacity, and another puzzling problem was solved.

Where there is an apparently wide variation between the turbine input and generator output, it is advisable to check first the meter connections and transformer ratio, or to check the switchboard instruments by connecting portable transformers and meters in circuit.

Applying Synchronous Motors to General Purpose Uses

By G. M. CHUTE
Industrial Engineering Department, General Electric Company

A GENERAL purpose synchronous motor has been developed that is comparable with the same type squirrel-cage induction motor. It has a starting torque equal to from 115 to 165 rated full-load torque and a pull-in torque of 100 to 125 per cent of rated full-load torque, and is built to operate at 100, 90 or 80 per cent full-load power factor.

ALTHOUGH synchronous motors have been successfully used for driving compressors, grinders and other machinery having low starting-torque requirements, they have often lacked some of the characteristics required to make them entirely successful for general-purpose application. The attitude still prevails that any synchronous motor is necessarily a machine having poor starting characteristics, requiring complicated control and skilled attendance and is easily injured when subjected to those disturbances which occur in most industrial plants. In spite of this attitude the power companies have been offering inducements for the improvement of power factor of industrial loads, causing an increased desire for the use of synchronous motors, mainly as a means of reducing power bills.

A need has therefore arisen for a general-purpose synchronous motor suitable for application to small industrial loads. Such a synchronous motor would be capable of correcting power factor, but would also have to be as simple, substantial in construction and efficient as other types of general purpose motors in which confidence has already been established by years of successful operation. The Electric Power Club has adopted standards that such a synchronous motor must meet in order to be considered suitable for general-purpose application.

The complete new line of synchronous motors recently placed on the market by the General Electric Co. meets the requirements of a general-purpose motor as specified by the Electric Power Club. These synchronous motors have been designed to give as satisfactory starting characteristics as the well-known squirrel-cage induction motor, and are made with some of the parts of the induction motors so as to be generally interchangeable with them. One of these synchronous motors may therefore be used to drive any load whose torque requirements have been successfully met by a standard squirrel-cage induction motor.

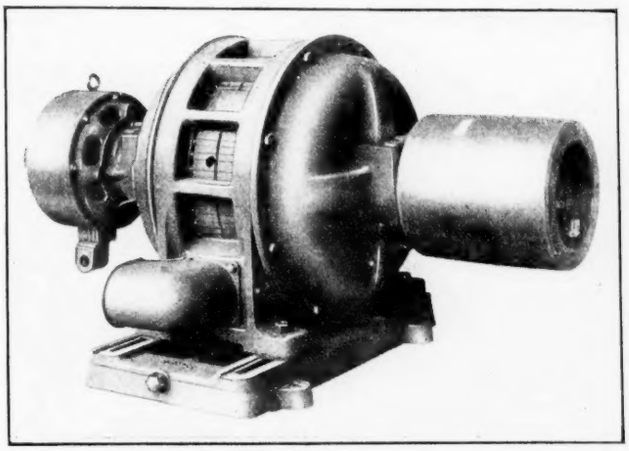


Fig. 1—General-purpose synchronous motor rated at 75 horsepower

This motor is of the revolving-field, salient-pole type, separately excited from a direct-connected exciter. An average size of motor is shown in Fig. 1. The exciter and its external mounting constitute the only external differences between this motor and the corresponding induction motor. The revolving member is shown in Fig. 2. A few details of the mechanical construction of the rotor are shown in Fig. 3.

These motors are now built in ratings from 15 to 200 hp. for operation on 60-cycle circuits at speeds from 600 to 1,200 r.p.m., and ratings at 1,800 r.p.m. will soon be added. Ratings are given at unity, 90 per cent and 80 per cent power factors, making it possible to

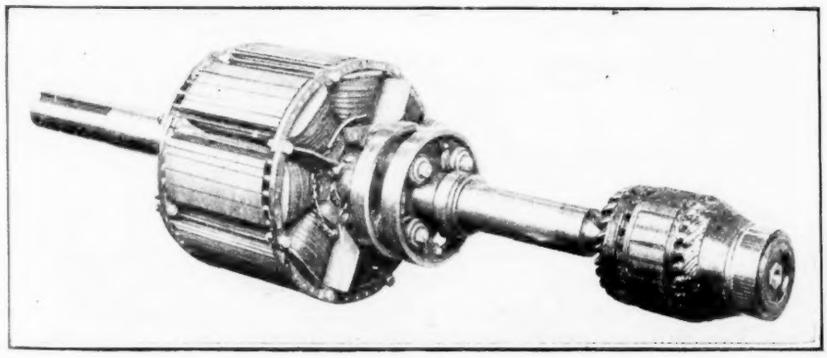


Fig. 2—Rotor of 40-hp. unity power-factor 900-r.p.m. motor

The starting winding in the pole faces consists of round brass and copper bars, silver soldered to copper end rings which are sectionalized to facilitate the removal of the pole if necessary.

choose a motor to give any desired amount of power-factor correction. The same windings are used for all power factors, making it possible to give one motor any of three ratings. For example, a motor rated 100 hp. at unity power factor could also be rated 90 hp. at 90 per cent power factor or 75 hp. at 80 per cent power factor without any change except decreasing the air gap of the leading power-factor motor by inserting shims under the poles.

The temperature rating of the unity power-factor motor is 40 deg. rise on all windings, measured by thermometer. When rated at 90 per cent or 80 per cent power factor, the stator coils do not exceed 40 deg. rise, with a rise not exceeding 50 deg. on the revolving field. Regardless of power-factor rating, each motor will carry continuous or intermittent overloads as satisfactorily and within the same temperature limits as any other type of 40-deg. general-purpose motor.

Starting and Operating Characteristics

The ability of these motors to meet certain torque requirements is probably best shown by means of the following tabulation in which all values are expressed in percentage of rated full-load running torque. Although starting at full voltage is not generally recommended, all values are given with full rated voltage applied to the motor terminals, for the sake of comparison.

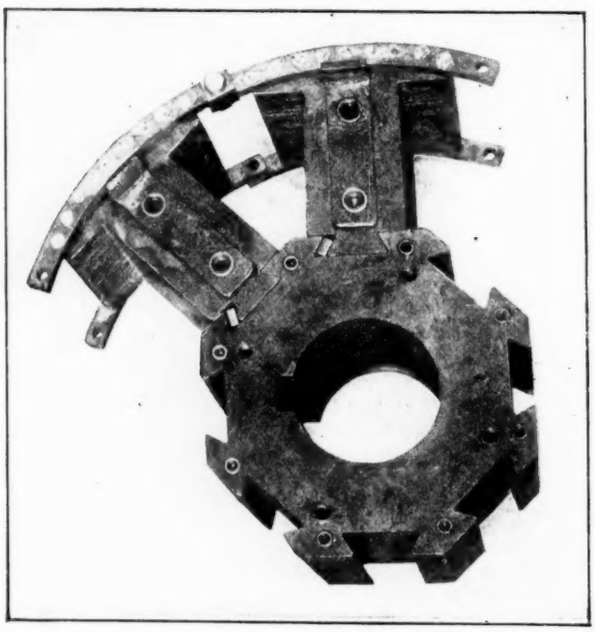


Fig. 3—Polepieces are dovetailed to the rotor center core

	R.P.M.	Rated Power 100 —Per Cent Rated	Factor, Per Cent 90 Torque—	80
Starting torque	1,200	135	150	165
	900	125	135	155
	720	120	130	150
	600	115	125	140
Pull-in torque		100	110	125
Pull-out torque		175	200	250

The starting and pull-in torques vary as the square of the applied voltage. Since the motor is generally connected to full-line voltage before field excitation is applied, full load can easily be accelerated up to full speed. This synchronous motor can, therefore, successfully drive any type of centrifugal pump.

The pull-out or maximum running torque of this synchronous motor varies directly with the applied voltage, so that the synchronous motor having 175 per cent pull-out torque will continue to run under conditions of low voltage equally as well as an induction motor having 300 per cent maximum running torque, since the torque of the induction motor varies as the square of the applied voltage.

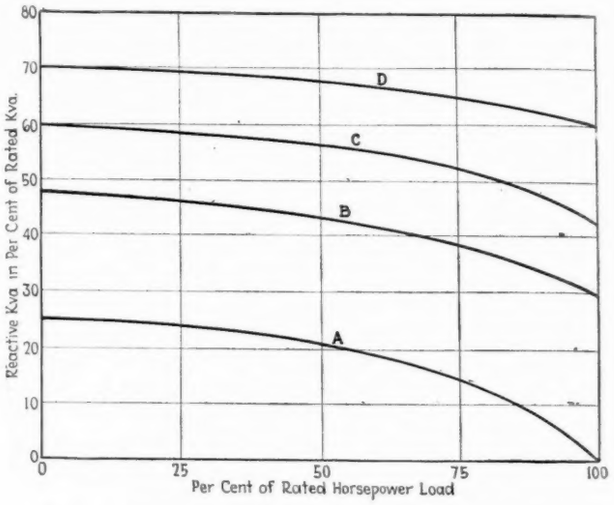


Fig. 4—Reactive-kva. curves for general-purpose synchronous motors

A—Unity power factor motor, normal 40 deg. rating. *B*—Unity power factor motor, field current increased to give 50-deg. rating. *C*—90 per cent power factor-motor operating with 50-deg. field temperature. *D*—80 per cent power-factor motor operating with 50 deg. field temperature.

When one of these motors is started, the current drawn from the power line is no greater than that required by the squirrel-cage induction motor that might be connected to the same load.

The efficiency at unity power factor is from 1 to 3 per cent higher at full load than the efficiency of the induction motor of corresponding rating. At leading power factors the full-load efficiency is approximately the same as that of the induction motor, but there the synchronous motor is not given due credit for the additional function of correction power factor, since efficiency is based only upon horsepower output. At partial loads the synchronous motor efficiency decreases more rapidly than that of the induction motor. But efficiency of the synchronous motor is not the only question, in view of the poorer power factor of the induction motor at partial loads.

Synchronous motors have often been damaged when permitted to operate for a short period without excitation, due to overheating of the amortisseur, or starting windings. The new motor, however, has an amortisseur winding so designed that it is not likely to be damaged, whether the motor fails to start or loses its direct-current excitation. When permitted to operate without field excitation, the amortisseur or rotor windings of the rotor will not be damaged any more quickly than the stator windings. Therefore, if the usual overload relays are placed in the alternating-current lines to protect the stator windings, the same protection is given to the rotor of the synchronous motor as to the rotor of an induction motor, and additional protective features

for the synchronous motor are unnecessary. Most overload relays will disconnect the motor from the line after several minutes, due to the increased alternating current when operating without excitation. If excitation voltage fails while the motor is carrying not more than half load, it will not drop below synchronous speed, remaining in step because of the salient-pole construction. This feature is probably true of all modern synchronous motors, built to operate at moderate speeds. A slow-speed motor would probably carry a smaller percentage of its load under similar circumstances.

The amortisseur winding consists of a grouping of round brass and copper bars, silver soldered to copper end rings which are sectionalized to facilitate the removal of any pole if necessary.

It is well known that, when operating at partial loads, the power factor of a synchronous motor becomes

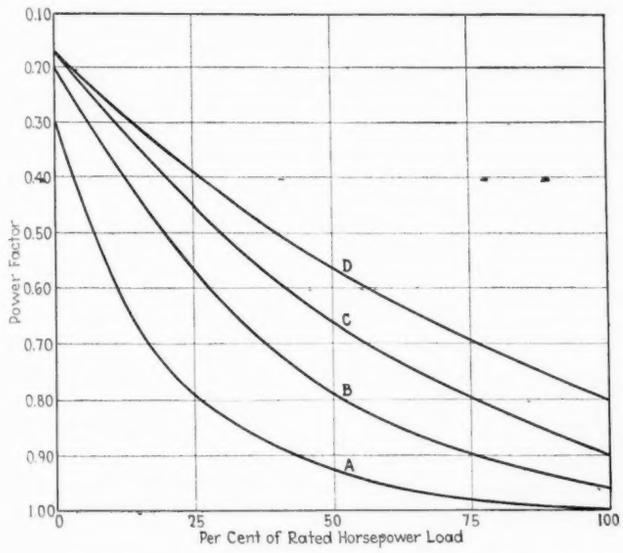


Fig. 5—Power-factor curves for general-purpose synchronous motors

A—Unity power factor motor, normal 40 deg. rating. *B*—Unity power factor motor, field current increased to give 50-deg. rating. *C*—90 per cent power factor motor operating with 50-deg. field temperature. *D*—80 per cent power factor motor operating with 50 deg. field temperature.

leading to a greater extent than its rated power factor. An incorrect impression prevails, however, that a unity power-factor motor operating at half load, for example, will operate with a leading corrective kva. equal to half its rated kva. input. The curves of Fig. 4 are presented to correct this impression and to show the corrective kva. that each type of synchronous motor can be expected to introduce into the power lines when delivering any part of its rated horsepower output, assuming that the excitation is maintained at the rated full-load value. The corresponding power factor is shown in Fig. 5.

As indicated by curve on Fig. 4, it is possible to overexcite the standard unity power factor, 40-deg. motor, thus raising the temperature of the field to 50 deg. and obtaining, as a result, considerable leading kva. and power-factor correction. This can be done without decreasing the ability of the motor to carry overload and without change of any kind except readjustment of field excitation. The excitation voltage of the unity power-factor motor at 40 deg. is so low that this overexcitation can be obtained without exceeding the rated voltage of the exciter.

Referring to curve *A*, Fig. 4, it will be seen that when operating at 50 per cent rated horsepower load, the unity power-factor motor will supply a reactive kva., to correct the power factor of the power system, equal to about 21 per cent of the motor's rated kva. At 100 per cent rated horsepower load the 80 per cent power-factor motor, curve *D*, supplies a reactive kva. to the system equal to 60 per cent of its rated kva. If the mechanical load is reduced to 50 per cent of the rated horsepower, the reactive kva. increases only about 7 per cent or to 67 per cent. At no load this motor will supply only about 10 per cent more reactive kva. than at full mechanical load.

In Fig. 5, which gives the power factor for the motors under different loads, it is found that the power factor of the unity power-factor motor, curve *A*, varies from 100 at full rated horsepower load to about 30 per cent leading at no load. For the 80 per cent power-factor motor, the power factor varies from 80 per cent at full rated horsepower load to about 17 per cent at no load.

Since these synchronous motors are intended to be the equivalent of induction motors in all possible respects, it is necessary to have control equipment as simple and dependable as that used with the squirrel-cage induction motor. In starting a synchronous motor, the closing of the field circuit is the only operation that is not also required on the corresponding induction motor. A starting device has, therefore, been designed using a standard type of induction-motor compensator for control of the primary circuit, with the addition of devices for automatically closing the field circuit as the motor approaches full speed. By its use any operator who is already familiar with the operation of an induction-motor compensator may start the synchronous motor. This starter provides complete overload and undervoltage protection.

Cheaper To Repair Than Scrap an Armature

There is a great difference between the cost of building a piece of equipment by manufacturing methods and producing the same article in a repair shop. When an armature has to be completely rebuilt in a repair shop, with a new winding and a commutator, the question may quite logically be asked, Would not it be cheaper to buy a new armature? In the manufacturing plant the coils, particularly, for the small and medium-sized machines, are generally made by girls, who become very expert in the work and who are provided with every facility for low-cost quantity production.

To make the coil in a repair shop usually means making up a form on which to wind them, and the work has to be done by an experienced armature winder. If not done by an armature winder, it requires considerable superintending by him. In spite of these handicaps, it will generally, except for small sizes, be cheaper by 25 to 50 per cent to rebuild the armature. If it can be conveniently done, it will usually be found cheaper to buy the coils and commutators unless the shop is well equipped for producing them. Then the time element of securing this material is also a factor that has to be considered if the machine is wanted back into service in a hurry. In many cases the material for making the repairs can be obtained in a much shorter time than a new armature.

Guess Methods in the Refrigerating Plant

By Charles L. Morgan

ONE day while the crew in the engine room was busy with some other trouble, one of the stuffing boxes on one of our 250-ton horizontal ammonia compressors ran so hot that a cloud of smoke began to spread around the room. I was rather new at the business at this time, and being the first one to notice the smoke, I hustled to the machine and gave it a shot from the liquid-injection valve. All the compressors in this plant were equipped with liquid connections to the stuffing boxes by which one could inject liquid ammonia into a stuffing box whenever it got too hot, which, by the way, is a practice I have discouraged since becoming more experienced with ammonia compressors. If such a connection is provided, it should be used only in emergencies, when the machine must be kept running and it is impossible to keep the stuffing box cool in any other way.

A Knock Appears

In a few minutes there appeared a knock in the compressor, that from all indications was somewhere in the suction or discharge valves. The machine was shut down, the valves taken out all around, and found to be in good condition and working freely. They were put back and the machine started, when the knock appeared again almost as soon as we had it properly started. Somebody suggested that we indicate the machine, so this was done, and we obtained some excellent diagrams. Having tried everything we could think of without results, someone finally suggested that the piston rings were loose, and being unable to think of anything else, we decided to shut the machine down the next day and have a look, and if necessary send the piston to a near-by machine shop.

About an hour before the time to change watches, the stuffing box began to blow badly, because someone had opened up too much on the expansion valves and the machine got cold, and at the same time the knocking got worse than ever. I tightened up on the gland and was much surprised to find that the knock almost disappeared while I was doing this.

Experimenting a little more, I found that I could practically stop the knock by tightening up on the gland as far as it would go; if I did this, however, it was too tight to run very long without heating, when we had to loosen it up and the knock started again.

Searching for the Trouble

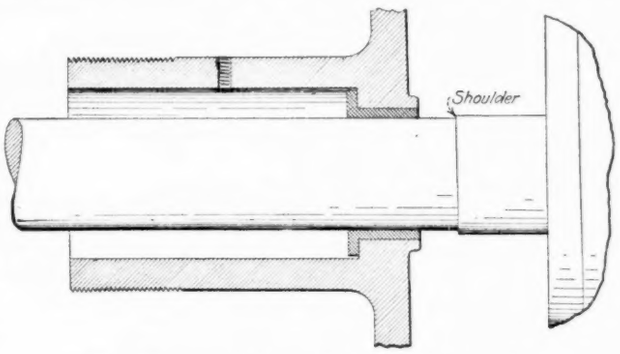
When I called the chief engineer's attention to this action, he had the machine shut down over night, pumped out and ready for opening the next morning when we came on duty. We removed the packing up to the oil lantern and found everything in fair condition, so we finally went ahead and removed the last half of the packing, which was found in good condition. Being unable to find anything in the stuffing box to cause the knock, we repacked the box again and started the compressor. When the machine got up to speed the knock came right back again just as bad as ever.

Tightening the packing reduced the knock, but if it was loosened to where it ought to run the knock came back as if a man were banging at the cylinder with a light hammer. We tried in every way to find the source of the trouble, even to shutting down the machine and filling the oil lantern with cylinder oil, which did not help matters in the least.

The chief finally ordered the machine shut down the second time and the packing taken out once more. After it was out, he had us turn the machine over slowly by hand, and this finally led to the detection of the trouble.

The construction of the stuffing box is shown in the illustration. Where the piston rod passes through the bottom of the stuffing box a babbitted bushing had been inserted. This was a very close fit on the rod.

When the stuffing box first ran hot it partly melted the babbitt in this bushing and shreds of packing worked in between the rod and the bushing. When I opened up on the liquid injection valve and practically froze everything solid in a few seconds, the babbitt solidified at once, and with it the pieces of packing, which now acted almost like a brake.



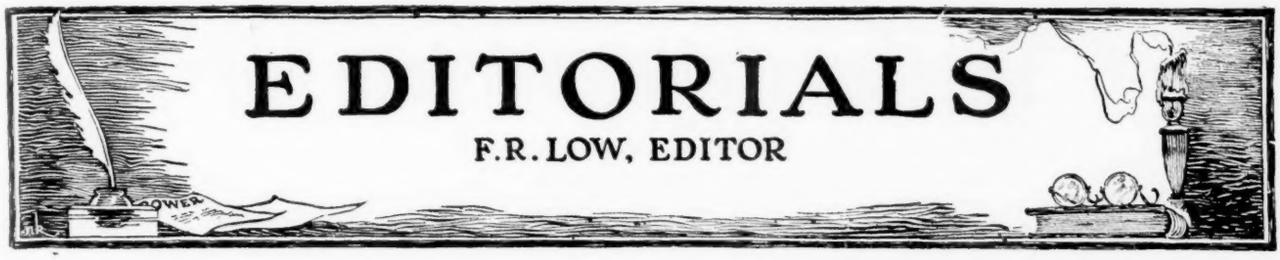
Shoulder on piston rod caused the trouble

What Caused the Knock

There was a $\frac{1}{16}$-in. shoulder on the piston rod at the point indicated in the sketch. When this shoulder entered the bushing it jammed the bushing on the rod, and pushed it back into the stuffing box for a short distance. When the piston reversed and started the other way, the bushing, being jammed on the rod, came back against the bottom of the stuffing box with a bang that had made all the noise. This also explained why the noise would be reduced by tightening the packing.

We finally got the bushing out by turning the machine around by hand. A few minutes' work with a blow torch softened the babbitt to a point where, by pounding it a little on all sides with a hammer, it became loose enough to be slipped over the end of the rod. After the bushing was rebabbitted and replaced, everything went along as nicely as before, but the chief gave all of us strict instructions not to use the liquid injection except when it was absolutely necessary.

The grounding conductor for an electric system should have an ampere capacity not less than one-fifth that of the conductor to which it is attached. In no case should the size of the grounding conductor be less than No. 8 B. & S. copper.



Steam or What?

THE substitution of some other material for steam as the working substance in a heat power plant is an attractive idea to those who know what is involved as well as to those who do not.

Realizing that about half of the heat of the fuel is wasted in the exhaust steam, many an ill-informed promoter has sought, sincerely or otherwise, to reduce this loss through the use of other fluids, and many a hard-earned dollar has been sped by false hopes into the coffers of the unscrupulous.

As the working substance in a simple single-stage boiler-and-engine cycle, it is hard to find a material better than steam. The exhaust loss is large, but is in great measure unavoidable. Hydraulic power cannot be increased by discharging the tail water into a hole in the ground, and the heat power cycle cannot be extended below the temperature of the surroundings.

On the other hand, there are possibilities for improvement through the use of two substances in the same plant, through the upper and lower ranges of temperature. Before the advent of the steam turbine and before modern developments permitting the use of high initial temperatures, the obvious point of attack was at the lower end of the process, but each attempted improvement entailed overbalancing faults.

Meanwhile, the turbine has developed effective use of steam at low temperatures, and improvements in plant equipment open the way for higher initial temperatures. Accordingly, the upper end of the cycle is the place to seek material improvements.

In considering the possibilities, power engineers should familiarize themselves with the basic thermodynamic principles set forth on another page of this issue, and be prepared to stand firmly against any extravagant or false claims made by misguided or rascally "inventors," who may seize this opportunity to prey on the gullibility of those whose money is of greater interest to the promoter than their welfare.

Think It Over!

AT A recent meeting of an engineering society a statement was made to the effect that it was desirable to give the gas-producer installations around the steel mills a good cleaning up so that the management might be tempted to visit them and see where their greatest fuel losses have been occurring. Almost everyone who is familiar with power plants will not have to think very hard to recall some installations to which the statement about the gas-producer plants might be applied. In more than one case where the management has been accused of lacking interest in his power plant and its engineer, a general cleaning up of the place might have attracted the desired attention.

Waste and rags for cleaning, paint, preventing leaks of steam, water and oil, and keeping the plant in general shipshape order are things that can be applied under almost any conditions, irrespective of the lack of executive interest. If the one who holds the purse strings happens to visit the power plant and finds everything in order, he will be more inclined to listen to the engineer's request for additional equipment to improve operation, than if he finds the place having a neglected appearance. It is quite logical to reason that if the plant is neglected, why spend good money on more equipment, which is likely to suffer the same way?

Mr. Engineer, if you are one of those who have been unsuccessful in attracting the attention of the big boss, think it over and see if the gas-plant indictment can be preferred against you. If it can, then the first thing to do is to clean the plant and put it in order.

The Possibilities of the Coal-Dust Engine

IN A recent editorial mention was made of experiments made on a reciprocating internal-combustion engine using pulverized coal as the fuel. Those who have measured the cylinder wear occasioned by the presence of even a small ash percentage in fuel oil will appreciate the difficulties to be overcome when a higher ash content exists in coal dust. That the test engine has been able to function for some three years indicates that some of the anticipated trouble has been overcome, although it does not insure the reliability necessary in commercial operation.

It would seem that the successful pulverized-coal engine must be one wherein there is no rubbing contact between a piston and cylinder or impingement on moving blades. Such a mechanism is by no means impossible, for the Humphrey gas pump, for which so much was promised a few years ago, apparently meets all the specifications of an apparatus in which an explosive mixture can be burned and the released energy converted into work without suffering from ash wear on any moving parts.

This pump consists essentially of a tank provided with valves to admit the fuel and air charge, which is exploded above a body of water; the resulting pressure causes the water to be forced out through a pipe, and a part is discharged at an elevation, while the remainder flows back into the tank along with a fresh supply to compensate for that delivered to the receiving tank or pipe. On the surface, there is nothing to prevent the application of a waterwheel to the discharge, so that the water energy is converted into electricity.

The operating difficulties encountered, so far, in using producer gas in the pump probably would not exist when auto-ignition compression pressures were used with pulverized coal.

When using gas, the advantage is with the reciprocating engine, but since coal is cheaper than oil or gas

on a heat basis, the Humphrey pump should prove more economical than an oil or gas engine. The objection to the use of oil in the pump is that self-ignition temperatures cannot be obtained save at excessive pressures, there being a large heat loss to the water during the compression phase. If pulverized coal were used, the ash would be mixed with the water and by proper design of the chamber it might be possible to insure an insulation of ash between the combustion space and the body of water, thereby reducing the heat absorption.

Inasmuch as the pump can be built in large capacities, it is not unreasonable to expect a pulverized-coal internal-combustion engine to be developed in the course of time. Certainly, the plan is worthy of some study.

Steam for Diesel Fuel Injection

MINDFUL of the cost of building the injection-air compressor used in Diesel engines, an engineer has suggested that steam could readily be used as the injecting medium, with the abandonment of the compressor. If the plan be at all possible, manufacturing costs would be reduced and operating troubles largely eliminated. Although in solid-injection engines no compressor is used, nevertheless, study of the combustion action in both types of engines indicates that a gaseous injection agent assists in the proper diffusion of the oil charge, although often at a loss in net brake horsepower over pump injection.

Unless there be difficulties that do not appear in preliminary studies, steam is apparently able to perform all the offices asked of the air blast and is obtainable at little if any cost. On the assumption of twenty-eight pounds of air charge per pound of fuel and of a five per cent air-injection requirement, one and four-tenths pounds of air is needed to inject a pound of oil. The work of compressing this air to one thousand pounds pressure amounts to over two hundred and fifty thousand foot-pounds, of which but thirty thousand are given up as velocity energy during the injection process. As the air drops to approximately atmospheric during the passage through the nozzle, the remainder of the compression work is not recovered. The volume of the injection is approximately six-tenths of a cubic foot.

If steam at one thousand pounds and in a saturated condition was supplied to the nozzle, it would have a temperature of five hundred and fifty degrees. To have the same volume as the air charge, slightly over one pound would be needed. In flowing through the nozzle to a five-hundred-pound condition, ten per cent of the steam would be converted into water and the energy available to inject the oil would be about seventy heat units, instead of but forty in case of air, indicating that a less amount of steam could be used, possibly under one pound.

Of advantage is the fact that the hot steam would warm the oil charge and by making it more fluid, reduce the weight of injection steam needed. As the steam temperature would be below the ignition temperature, there would be no risk of explosions. In view of the fact that the steam temperature would always correspond to the pressure carried, the chilling effect of the air blast would be eliminated and the oil would enter in a heated condition, thereby permitting a lowering of the compression temperature and pressure while maintaining automatic ignition.

Steam could be made readily available by the introduction of a small tube boiler in the exhaust passages. While a thermometer may register seven hundred degrees at the exhaust manifold, the gas temperature is much higher at the point of release. By providing ample heating surface to evaporate an amount of steam equal to the weight of oil used in the engine, a pressure of one thousand pounds is attainable. Inasmuch as the heat recovered by the steam is at present wasted, apparently the plan offers a prospect of a saving of about five per cent in the fuel consumption and a reduction of the engine capital investment of some ten to twenty per cent.

Power Demands of Condenser Auxiliaries

IN THESE days, when so close attention is given to high boiler efficiency, to the steam-turbine cycle and to details of bleeding and reheating, one must not overlook the small but important savings in the power demand of condenser auxiliaries. There are few even among our largest central stations where studies of such equipment will not develop worth-while savings. Many such auxiliaries are electrically driven, so that any power saved in their operation becomes at once available as salable power to consumers and hence has a greater money value than power in the high-pressure steam only.

Circulating water pumps are generally provided with means for variable-speed drive. Yet one often finds the operators running these at full speed when the load conditions would permit a much lower speed and hence a lesser power demand. In some plants studies may indicate that there are certain vacua that it does not pay to exceed when all factors are given consideration. When such limits are known, definite instructions can be given for the operation of the circulating pumps, depending on water temperatures. Also studies of the effect of cleaning on vacuum and pump capacity will permit definite cleaning times to be set.

The designer can still improve condensers so as to lessen the head losses at entrance to and exit from the tubes, the eddy losses in the water boxes, and the velocity head loss at the circulating-water discharge.

One frequently hears it said that steam-jet air pumps take more steam than their guarantees. This is sometimes due to erosion in the steam-jet nozzles, but more frequently to closed nozzles. This difficulty can be lessened and often overcome by the use of some of the newer non-corrosive alloys for the construction of these nozzles. Steam-jet air pumps should be checked from time to time to see that they are not wasting steam and are working efficiently.

In some cases the condensate is not as warm when leaving the hotwell as it should be considering the prevailing vacuum. This may be due to the refrigerating effect of some of the cooling-water tubes, to light loads or to the fact that insufficient passageway was provided for exhaust steam to travel around to the hotwell. In a recent case this temperature was greatly improved by changing the bleeder drip piping from the side of the condenser directly into the lower part of the hotwell. Similar minor changes may achieve equally desirable results in improving operation in plants suffering from chilled condensate.

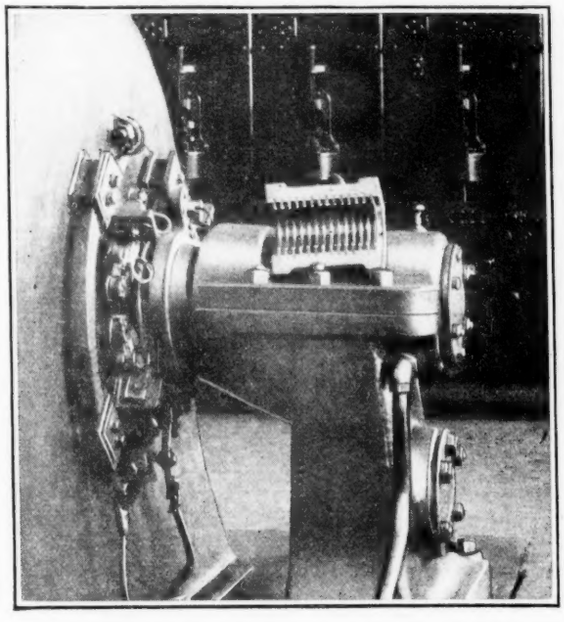
These savings in condenser auxiliary power, though individually small, have an important effect on over-all plant economy, for the condenser usually has more service hours than the main unit to which it is connected.

Practical Ideas From Practical Men

Manufacturers Do Not Always Appreciate the Engineer's Difficulties

That manufacturers do not always foresee or appreciate the difficulties of the power-plant engineer is apparent from an incident that came up recently in connection with some repairs for one of our turbines.

A 750-kva. unit was being operated at considerable overload, while a larger and more modern unit was being installed. One night at 2 a.m. I received a call from the operator saying that the bearing on No. 1 turbine was burned out. As it was essential that the



One-half of the relined thrust bearing

turbine be back in operation again as soon as possible, I went at once to the power plant.

When I arrived at the plant, smoke was still issuing from the governor end main bearing, so we proceeded to remove the turbine rotor and install a new bearing, but our trouble was not to end there. When the turbine was again put in service, the new bearing remained normally cool until after the machine was on the line, when it began to heat almost immediately. It then occurred to us that, as the heat developed as the generator became loaded, the trouble must be caused from end thrust on the turbine rotor. We proceeded at once to remove the governor and examine the thrust, and as we had anticipated, several rings were found broken in the thrust bearing, one-half of which is shown in the illustration resting on top of the outboard bearing. We wired the manufacturer, requesting that a new bearing be shipped at once by parcel post.

The manufacturer replied that the bearing was being sent, but under protest, as we would be unable to get satisfactory service unless the bearing was installed by one of the company's engineers.

This attitude, combined with our urgent need for the machine, caused us to decide upon an emergency repair. A visit was made to a near-by foundry, where we managed to procure a piece of bronze of suitable dimensions. We then machined the bronze to the exact bore of the rings, facing each ring to the exact size of the rings in the thrust bearing.

When the bearing was installed and adjusted for proper thrust, the machine was again placed on the line, and it operated satisfactorily for several months.

Escanaba, Mich. S. U. ROGERS

Improperly Installed Relief Valve Caused Bursting of Turbine Casing

On long penstocks connected to hydraulic turbines, relief valves installed and in working condition, at the turbines, are an important part of the equipment. In one installation where three units were sold to a mining company, they did not desire the service of an erecting engineer, and as it was not a very important job the manufacturer did not unduly persuade them. A consulting engineer was there on other work, and he supervised this part of it also, but unfortunately had to leave before it was completed.

The master mechanic had started up the plant and everything went well until a week later, when there was a bad electrical storm and all three units were tripped off the line at once. The effect of the storm brought a hurry call for help, for according to the report the turbine casings had burst and washed away half the camp. These turbines were installed at the end of a 48-in. pipe-line, 1,800 ft. long, and one can about imagine what would happen if the relief valve did not function, when full load was suddenly rejected.

When I reached the place, I hired a small truck to take me and my kit to the plant. The driver surprised me by saying that the plant was running again. Piles of rubbish, lumber and stone still lay at the lower part of the valley to tell what had happened.

The turbines were of the horizontal-shaft type with a relief valve connection cast on the spiral casing. Two of the units had the relief valves blown off. The other unit seemed to have had its relief valve properly connected, which the superintendent told me he had done himself, after discharging the alleged master mechanic. The units that had the relief valves blown off were plugged with wooden plugs wedged in and braced against coming out by strap-iron connections. An examination of the relief valves that had been blown off showed that the amateur mechanic had bolted them on backward and had not connected the dashpot and levers, since they didn't fit the way he had them. New spiral casings were rushed through the shop and one of our construction men completed the work of installation.

Boston, Mass. M. B. THURSTON.

Reducing Lineshaft Friction Saves $5,400 a Year

In a certain mill a 120-hp. motor was driving a lineshaft to which it was desired to connect a new production unit requiring 15 b.hp. The main driving motor was heavily loaded, and it seemed to be a necessity either to replace it with a larger motor or to install a 15-hp. motor as an individual drive for the new machine.

After a careful study the plant engineer estimated that at least 10 hp. in friction could be saved by substituting roller bearings for the babbitt bearings then in use and that a further reduction could be made by substituting silent chain drives for the belts. This would eliminate the friction caused by the high belt tension necessary with the short lineshaft centers in this plant.

The shafting was 3 in. in diameter, with bearings every 8 ft. There were six double-width steel pulleys, 54 in. in diameter, on the drive shaft and 24-in. steel pulleys on each driven machine, with idler pulleys in addition.

On Sunday morning when the plant was idle, the machine loads were taken off the motor by shifting the belts to the idler pulleys, where the machines were equipped with them, and on those not having idlers the load was taken off by driving the key out of the gear at the point where the pulley shaft delivered power to the machine proper. This arrangement left the belt tension on the bearings and gave as near as could be obtained the friction load on the system. As the motor was on an individual circuit, equipped with ammeter and voltmeter of certified accuracy, the power delivered could be determined with ease.

Upon running this idle shafting and belting, the motor showed a power consumption of 35 b.hp., and after running for a considerable time, so that the bearings were well oiled and working normally, the load dropped to 34.5 b.hp.

When these figures were shown to the management, the decision was made to try out the proposed improvement on one lineshaft and orders were placed for the required number of sets of roller bearings and suitable silent chain drives for one complete unit. When the new equipment arrived, additional tests were made, first with the new roller bearings and the old belting which showed a reduction in friction load of 8 b.hp., reducing the total power required by the shafting and belting to 26.5 b.hp. Substituting the silent chains for the belting gave a further reduction of 4 b.hp. The energy consumed in the transmission thus was reduced to 22.5 b.hp., showing a total power saving of 12 b.hp. The new machine, therefore, was put on the line, as a maximum requirement of an additional 3 hp. could be met by the original driving motor.

While the cost of the silent chain drives and the roller bearings was considerably more than that of a new 15-hp. motor, it was much less than would have been the cost of a new motor large enough to handle the entire load. The cost of this equipment could not be charged entirely to the new unit, as it benefited every machine on the line, so in figuring the savings made, it was agreed that the initial cost of the items previously mentioned should be charged off entirely. At a conservative estimate it was costing 1.6c. to deliver 1 kw.-hr. to the lineshaft. The power saving on the one lineshaft was 12 hp., or 9 kw., and as the plant operated 313 days a year, 24 hours a day, the yearly saving amounted to at least $1,081.

In view of this showing the management approved the installation of silent-chain drives and roller bearings for the other four units in the plant still operating under the old conditions. As the reduction in friction load approximated that shown by the first unit, the annual saving was $4,324. Adding this to the saving made by the first unit gave a grand total of $5,405.

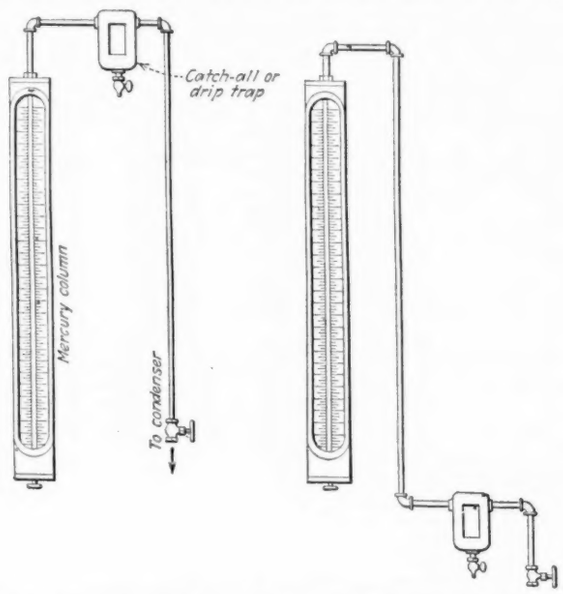
In addition to the saving in power there were other advantages. Belt slip has been eliminated, resulting in smoother machine operation. Where formerly it was necessary to carry 5 volts over the normal 440 on the driving motors, to speed them up slightly, the motors are now run at normal voltage and have plenty of speed for the driven machines, resulting in smoother and more efficient operation in the production department. Oil bills for the lineshaft bearings have been reduced materially and one oiler on each shift has been eliminated.

Chicago, Ill. LYNN LLOYD.

Right and Wrong Way of Connecting Mercury Vacuum Gages

For the purpose of diminishing fouled mercury columns on jet condenser installations the accompanying piping method will prove helpful.

For several years the mercury vacuum gage on a jet condenser was piped as shown at the left in the illustration. It was found necessary to strain the mercury through cheese cloth frequently to remove oxidation, and also to clean the glass tube, for the purpose of removing particles of mercury adhering to it.



Gage connection shown at right obviated the trouble

After arranging the connection as shown at the right, no further trouble was evidenced. The gage has been in service almost three years since the change was made without having been disassembled, and shows no further indication of fouling.

The use of brass piping for gage lines is also essential, and the joints should be covered with a generous coating of shellac. A needle valve interposed between the mercury gage and the condenser permits work to be done on the gage when necessary without allowing air to be drawn into the condenser. E. A. BAERER.

Jersey City, N. J.

Comments from Readers

Operating Schedules and Their Use in Hydro-Electric Plants

The article by Paul F. Kruse in the April 13 issue on "Operating Schedules and Their Use in Hydro-Electric Plants" interested me considerably, because I have made some theoretical investigations on the subject of operating schedules and incremental efficiencies and their application for dividing loads between prime movers on the basis of maximum efficiency.

My investigations lead me to the general rule as follows: For maximum efficiency of the power plant, the full load must be so divided that all units will have the same incremental efficiency. This rule may be applied for all prime movers as steam, oil or water.

Identical units, in general, must be loaded equally. However, as in the case described by Mr. Kruse, the power discharge curve, nearly to the point of maximum efficiency, is a straight line and therefore the incremental efficiency curve is a horizontal. Then the load between identical units, in these portions of the curve, may be distributed at will. However, by operating beyond the curve of maximum efficiency, where the incremental efficiency curve is not a horizontal line, my rule must be applied, in which case loads of 10,000, 10,500 and 11,000 kw. on No. 5 unit would correspond to loads of 6,400, 6,600 and 6,800 kw. on Nos. 1 to 4 units. At these points the turbines have the same incremental efficiency. N. SAKHAROFF.

Leningrad, U. S. S. R.

Checking Machine Alignment

I have read *Power* for many years and always enjoy some item of cause or cure for trouble which is published, because it is either a new idea to me or one that I was made familiar with through some breakdown, repair or "off-peak' experiment. The article in the issue of June 1, "Checking a Large Rotor's Shaft Under Difficulties," calls to mind once checking a large rotor shaft supposed to be sprung, and how the trouble was located. As in Mr. Rea's case, this was a vertical-shaft, waterwheel-driven generator which vibrated badly under load.

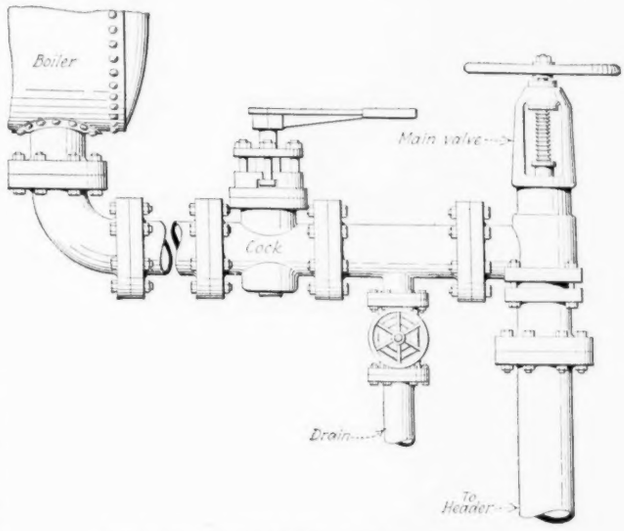
The first step was to take out the coupling bolts, run the waterwheel up to speed and check the bottom half of the coupling with an indicator, which showed that when the coupling had been heated for pressing on the shaft, it had warped 0.004 in. and had not been corrected before the generator rotor was connected, therefore the bearing was considerably out of line. In many cases of out of level, if the generator erector took time to check the level of the waterwheel before and after setting the generator, he could save the expert erectors many useless trips.

One other way to check the truth of a shaft without tearing a machine down, is to remove the top bearing only and use an indicator on the bearing surface; if the shaft is out of truth, the indicator will show not only how much but where on the circumference. I could cite many more cases of cause and cure in large rotor vibrations, both curable and incurable. In the last twenty years the companies making these machines have corrected most of the defects, so now the average erector has very few new or novel experiments to perform when installing machines which, the chances are, the customer's operating force have been familiar with for years. Turbine shafts operating with high-temperature steam would be an interesting subject to hear from some of your readers about. C. WILEY.

Chicago, Ill.

Arrangement of Boiler Blowoff Valves

In the reply to the question in the March 23 issue on the proper arrangement of boiler blowoff valves, the recommendation is made that the valve be placed next to the boiler and the cock on the line side. It appars



Drain is provided between cock and valve

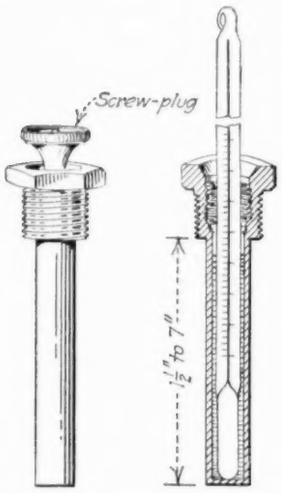
to me that this arrangement should be reversed, so that the valve, which is more likely to leak owing to wire-drawing, would not be subjected to boiler pressure except while blowing down. I am aware of the fact that there is great diversity of opinion on this subject, including both arrangement of valves and order of operation.

A desirable feature at this point, where there are two or more boilers in the plant, is a small drain installed between the cock and the valve. When the boiler is being cleaned internally, the drain will allow the water to run off conveniently and the men inside the boiler will be protected by the main valve, which will prevent water backing up should another boiler be blown down. The sketch shows a possible arrangement. JULIAN HARVEY.

Detroit, Mich.

Types of Thermometer Pockets

Referring to the article on page 685 of the May 4 issue on "Types of Thermometer Pockets," it is doubtful whether the thermometer wells illustrated would be less expensive than standard thermometer wells made from one piece of steel, which are available in sizes from 1½ up to 7 in., as shown in the accompanying illustration. In Fig. 3 of the article referred to is shown a well for use in a vertical pipe — evidently arranged so that the liquid will not run out of the well. The same object can be accomplished with a one-piece standard thermometer well by tapping the pipe at an angle, which is the general practice. The point that I wish to emphasize the most, however, is the fact that the method of installing a thermometer pocket as shown in Fig. 2, is bad practice, because the thermometer is located in a dead pocket and will show inaccuracies of 50 deg. or more, depending on the temperature to be measured. In order to obtain an accurate measurement of the temperature, the bulb must project into the pipe line or there must be a vent at the top of the well to permit circulation past the bulb of the thermometer. The insulation shown around the thermometer well in Fig. 2 will only serve to protect the thermometer from fluctuations in outside temperatures, and the error from this source will be negligible compared with that due to the method of installation, as previously explained. The thermometer shown in Fig. 2 will indicate the temperature of the air space surrounding the thermometer pocket and not the temperature of the contents of the pipe line.



Standard thermometer wells are made in lengths of 1½ to 7 inches

J. W. SCHWARZ.

Rochester, N. Y.

Engineering and the Man

Referring to the letter in the May 11 issue by George F. Marstellar, on "The Man and Engineering," in which he advocates a six- or seven-year course in engineering to raise the professional standing, I doubt if such a course would improve results.

Science and theories may be elevated to the point where the essential elements are neglected as being of questionable value due to the lack of practical experience. Some years ago I had an experience with an intellectual who actually believed he could succeed in proving his superiority while I was on my vacation. But his total ignorance as to the principles of simple jigs and tools and their construction and application proved to be his defeat even in the case where he was supplied with sketches and told to hold his drawing up until my return. His ambition to shine in my absence caused him to ignore orders, with the result that a few castings were scrapped and his reputation shattered.

The reference made in the letter by Mr. Marstellar to Ford automobiles and engineering graduates and the methods used to turn them out in large numbers may be similar, but the result is far from being equal or satisfactory. A Ford is the result of the combined effort of specialists who are what may be considered the connecting links in the sequence of operations necessary to the manufacture of an automobile.

An engineering graduate is the product of a system of training that can supply only a limited knowledge on many subjects, the greater number of which he will never apply even if he be one of the 16 per cent who utilize such a course of training.

Modern production methods do not call for the application of general knowledge on the part of any individual or group, nor is the ability to discriminate considered an essential element.

A "Jack of all trades" is usually master of none and may lack ability as a successful organizer. General knowledge and limited information on any one point is of little real value.

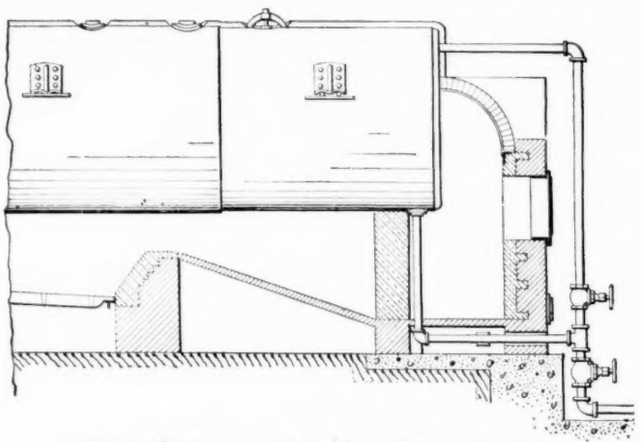
About all that can be expected in an engineering course is general study of many subjects dominated by those who are educated in a general way, with the result that they are prone to reproduce their kind.

Application and the ability to discriminate are the chief elements necessary to success; the failure to do so may account for the small percentage of graduates who utilize anything out of the result of their study and drift into lines outside of engineering.

Cleveland Heights, Ohio. JAMES MCINTOSH.

Protecting Blowoff Lines

On page 789 of the May 18 issue W. A. Fisher shows a method (reproduced herewith) of connecting a circulation pipe as a means of protecting the blowoff lines of a return-tubular boiler. This method I believe is in more or less general use, but in my opinion the top pipe should be connected below the water line instead of into the steam space, as Mr. Fisher suggests. It is obvious that the only circulation possible with this connection will be the small amount of condensation in the outside pipe. In some cases where a circulating connection of this kind is made with the top connection at or just below the water level, a valve is used on the horizontal bottom connection, outside the boiler setting, to permit using the upper connection as a surface blowoff independently of the regular boiler blowoff.



Method of preventing blowoff pipe trouble

Toronto, Ont., Canada. JAMES E. NOBLE.

Is Race an Obstacle?

The letter by Andrew C. Miller in the May 11 issue has a lot in it when read between the lines. It is, of course, difficult for a white man to see the colored man's point of view, but I believe I do see it. I have lived practically all my life in the North, principally in New York State, where the colored man is supposed to be equal to the white man in a good many ways. In the city where I lived is a certain trade school with a good-sized power plant in which the chief engineer is a colored man who has been there over fifteen years. The power plant is one of the show places of the city. The engine-room crew is composed entirely of white men who have been with him a good many years. This chief is a member of two engineering organizations, in one of which he has been treasurer for many years.

He holds a chief engineer's license covering anything in the city, is highly educated, and is well thought of in both engineering organizations. So much for the colored man in the North.

I am now employed as engineer in a distilled-water ice plant in North Carolina. As is the rule throughout the South, the negro does practically all of the manual labor. Our ice pullers, firemen, oilers and wagon men are all negroes. Also wages in the South are much lower than in the North and the hours much longer.

I have in my engine-room crew a young colored fellow who is a good mechanic and a good operator and has been known in an emergency to operate the entire plant for 36 hours without assistance. He is rated on the payroll as an oiler, whereas if he were in the North he would be rated as an engineer and draw engineer's pay.

The white people in the South are always lamenting the fact that the colored man never amounts to anything. But they are probably more to blame than he is for depriving him of any chance to do anything but menial work.

Personally, if I wanted to hire an engineer, either chief or assistant, and a colored man came to me with proof of his ability, he would have just as much chance as a white man. I cannot see why the color of a man's skin should make any difference. R. G. SUMMERS.

Clinton, N. C.

Analyzing the Power-Purchase Problem

In the May 18 issue the article "Analyzing the Power Purchase Problem," outlines thoroughly the factors that may swing the decision to purchase power or vice versa. According to the figures for that plant the main advantage of the private plant is dependability, as the cost figures favor the plan of power generation by a negligible sum. Considering the extra investment of $587,000, the return of $10,060 per annum looks small and few business men would be satisfied with it if only cost figures were being considered. Only two sources of supply were discussed, and it would be interesting to know the decision of that company. A third method, suggested in a recent editorial in *Power*, is the middle course—to install only enough generating capacity to supply by the turbine exhaust, the required process steam.

Even when purchasing all power, $459,640 must be invested, and by a slight additional investment one non-condensing turbine could be installed to operate in parallel with the central station. Under this plan no reserve capacity is needed, as the load can be shifted at any time from the turbine to the power company's plant. Since only the process steam will be passed through the turbine, there is no need of additional boiler capacity. As this plant operates 6,350 hours a year and requires 14,000 lb. of process steam as the minimum demand and over 59,000 lb. maximum, considerable byproduct power can be generated. Installing a 1,000-kw. unit which would operate at full load day and night 5 months in the year and at half-load for the next 4½ months and quarter-load for 2½ months, would give, in 6,300 hours of operation, over 4,000,000 kw.-hr. annually. This method shows a fairly high load factor for the turbine, which reduces the fixed charges per kilowatt of capacity. More power could, of course, be generated by having a 1,500-kw. non-condensing unit to handle the winter load where the process and heating load demand 59,000 lb. per hour, and a 500-kw. unit to operate at lighter loads, but the investment in generating units would be doubled and the load factor reduced. A 1,000-kw. turbine could be installed for approximately $38,000, no condenser equipment being required, and the cost of operation would be about as follows:

Fixed charges at 12½ per cent	$4,750
Fuel	5,800
Operating labor and supervision	8,000
Miscellaneous	500
Total	$19,050

With an average water rate of 50 lb. per kw.-hr., the 4,000,000-kw. annual output requires 200,000,000 lb. of steam, 10 per cent of which is chargeable to power. With coal at $5.79 per ton the steam cost should be around 29c. per thousand pounds for fuel alone. The reduction in the purchased power bill at 1.5c. per kw.-hr. is $60,000 annually. The net saving appears to be high enough to return the cost of the turbine in one year, but this is by no means a certainty. The plant is complicated by the plan of parallel operation, which the power company might not consent to, and since it reduces the quantity of purchased current, there is no assurance that the same power rate would apply for the smaller block of power, as is used where the power company handles the total load. Assuming that the power rate for the balance is increased to the extent of 20 per cent, there is a net yearly saving of $26,336, which is sufficient to justify the expenditure of $38,000.

Possibly the figure of $8,000 charged to labor and supervision for the turbine cannot be justified, since three shift engineers would be required anyway to care for auxiliary equipment and the addition of the turbine might call for only one extra man at $2,500 or two men costing $5,000 for labor and supervision. The figures in the article referred to allow only $7,675 for labor with a complete generating plant of three units. In any case the purchase of all power cannot be justified, since the investment in a 1,000-kw. generating unit earns from 70 to 100 per cent each year of operation. The generation of all power may be justified by insurance against production loss, as I have been in plants that used both generated and purchased power, and in one year I have witnessed ten interruptions of service from purchased power, while the generating unit operated 23 hours daily for a year with no shutdown except when power was not needed. Conditions beyond the control of either party were responsible for the interruptions. A. F. SHEEHAN.

Brightwood, Mass.

New and Improved Equipment

"Rotator" Air Heater

The illustrations show a type of preheater manufactured by Rotator Maschinenfabrick und Apparatebau, Charlottenburg, Germany. Fig. 1 is an assembled view of the heater and Fig. 2 shows the constructional details.

The heater is built in sections consisting of a number of square or rectangular plates of thin sheet iron, having a narrow strip along two parallel edges bent at an angle of about 50 deg. in one direction and on the other two parallel faces, in the opposite direction, as indicated by the alternate black and light sections in Fig. 2. When the plates have been assembled, they are welded along the edges to make them air and gas tight.

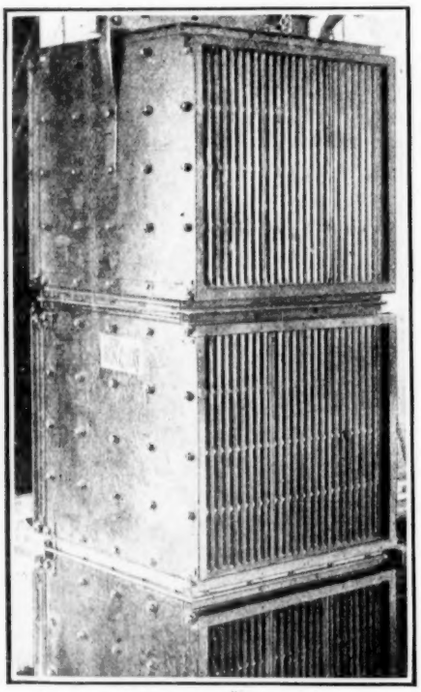


Fig. 1—Heater is built in sections and assembled into units

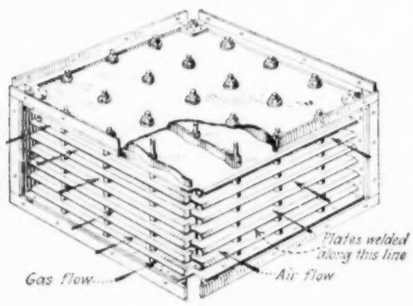


Fig. 2—Section of heater showing constructional features

In Fig. 2 is shown the method of reinforcing the plates over their entire area by using ring spaces around the through bolts and spacer strips running the full length and width of the plates. This method of staying permits the use of thin sheets. The plate assembly is sealed at the four corners by the angle-iron frame and asbestos packing.

The sections are readily assembled, as indicated in Fig. 1, into units of various sizes to suit installation requirements. In the view shown, the gas flow is horizontal and the air flow vertical.

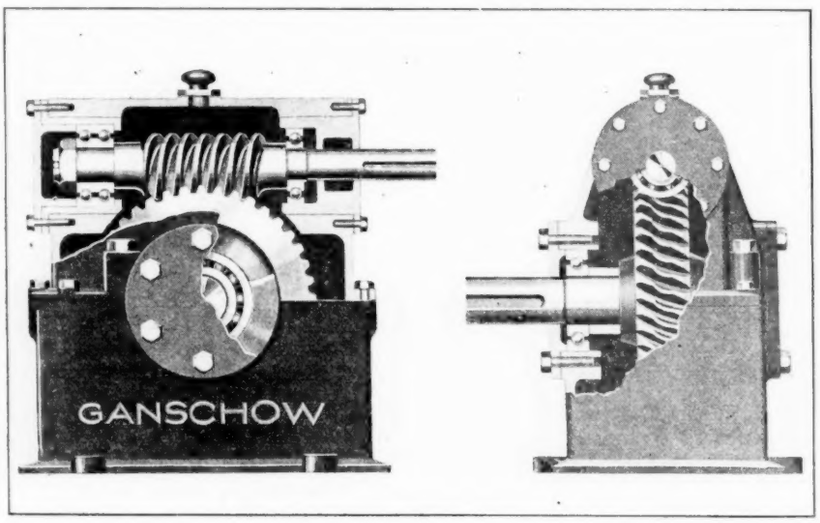
Ganschow Worm Gear Speed Reducer

A type of worm-gear speed reducer brought out recently by the William Ganschow Co., 1009 Washington St., Chicago, is shown in the illustration.

Standard units are equipped with a special bronze gear, the face width of the gear being designed so that the unit pressure load is much below the safe working stress of the metal. The large units have a bronze rim shrunk and studded on a cast-iron center, while the smaller units have a solid bronze gear.

The material from which the worms are made is 3½ per cent nickel steel S.A.E. No. 2320. The casing on the worm threads has a scleroscope hardness of 80 to 85. The pressure angle of the worm thread is 22½ deg. on the axial section.

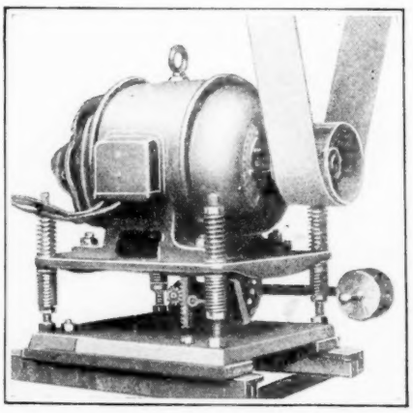
Anti-friction thrust bearings are used throughout. Either ball or roller bearings may be fitted according to the service demands. Bearing sizes are calculated for starting torque load with entire load concentrated on one bearing. The span of the worm bearing has been kept short to minimize the shaft deflection. The gear housing is symmetrical, and either worm or gear shaft extensions may be reversed. The gear bearings are held in place by clamping plates, as in the duplex worm thrust bearing. The front radial worm bearing is free to float to compensate for expansion due to heat.



Cut away views of worm gear speed reducer

Spring Motor Base

The illustration shows a spring motor base, designed by the Motor Base Co., Frankfort (on-the-Main), Germany, to provide a ready means of securing the proper belt tension. The base to which the motor is attached permanently, is carried on four studs having springs above and below the base, each of which is adjustable to give the proper tension. To preclude the possibility of vertical vibration of the motor from any cause, a counterweight is at-



Motor supported on a spring base

tached to the motor base by means of a lever, pinion and rack as shown. By throwing the counterweight over to the opposite side to that shown, the motor is raised, and this permits immediate stoppage of the belt. The base is made in various sizes to meet any requirement, and additional springs are provided for especially heavy motors.

Bonded Arches of "Mech" Brick

A type of flat arch developed by Loyd R. Stowe, Railway Exchange Bldg., St. Louis, Mo., is shown in the accompanying illustrations. Small tile or, rather, brick are used with the standard 2½x4½-in. face to the fire. At the opposite end one side of the brick is indented, so that in pairs they may be slipped along the flanges of opposing hangers, which

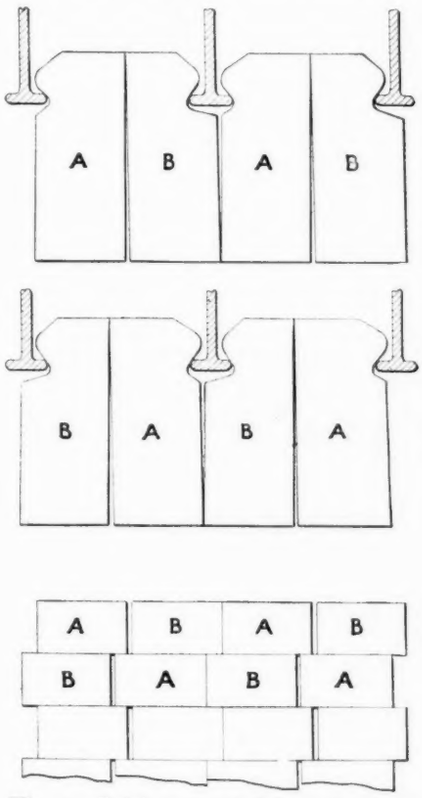


Fig. 1—Brick supported in pairs from hangers

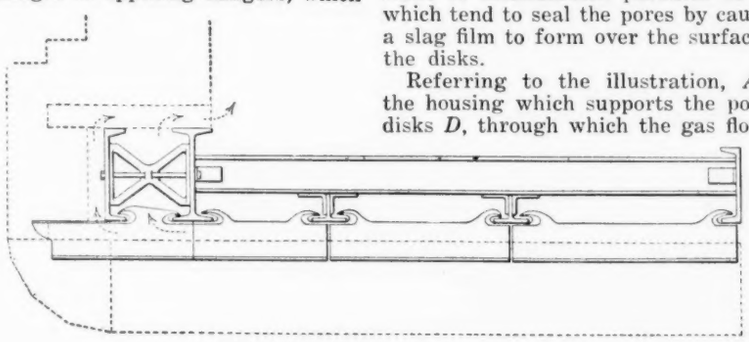


Fig. 2—Steelwork of the arch

are spaced on 9-in. centers. On one brick the notch is deeper than on the other, as indicated in Fig. 1, so that the joints are offset with respect to the hangers, being to the left of the center in one course and to the right in the next course, in which the bricks have been exchanged. This construction breaks the joint and bonds every brick, and with the spacing shown between bricks there is sufficient room for expansion to prevent spawling.

Fig. 2 shows the steelwork. To guard against deflection, the supporting structure is made up of comparatively heavy beams on wide spacing. Cross-members of the shapes indicated make it possible to use short lengths of cast-iron brackets which slide along the lower flanges. The features claimed for this construction are rigidity, flexibility and ease of renewal for both brackets and brick.

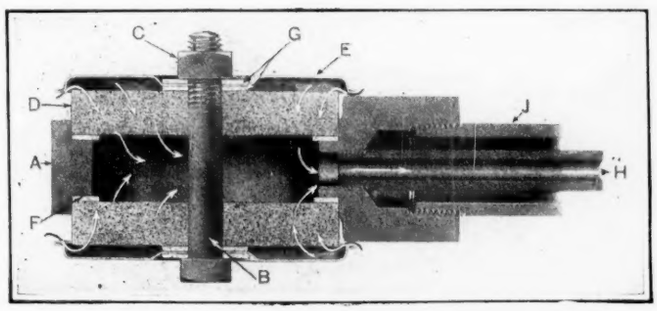
Uehling Improved Pyro-porous Gas Filter

In the Dec. 12, 1922, issue a Pyro-porous gas filter for use on gas sampling lines to CO_2 recorders, developed by the Uehling Instrument Co., 475 Getty Ave., Paterson, N. J., was illustrated and described.

This filter consists essentially of two porous disks mounted in a special casing which is connected to the end of the gas sampling line inside the boiler furnace, the disks possessing the necessary refractory qualities to resist the high temperatures.

Recent improvements made to this filter include changes in the design of the casing to permit supporting it independent of the gas sampling line, and the employment of metal shields to protect the porous disks against impingement of incandescent particles of ash which tend to seal the pores by causing a slag film to form over the surface of the disks.

Referring to the illustration, *A* is the housing which supports the porous disks *D*, through which the gas flow is indicated by arrows. The shields *E*, which protect the porous disks, are held in place by the clamping bolt *B* and nut *C* with sealing washers *G* and *E* inserted as shown. The filter is supported in the boiler setting by the pipe *J*, the gas being conducted from the filter through the pipe *H*. The filter is designed for use in temperatures ranging from 200 to 1,400 deg. F.

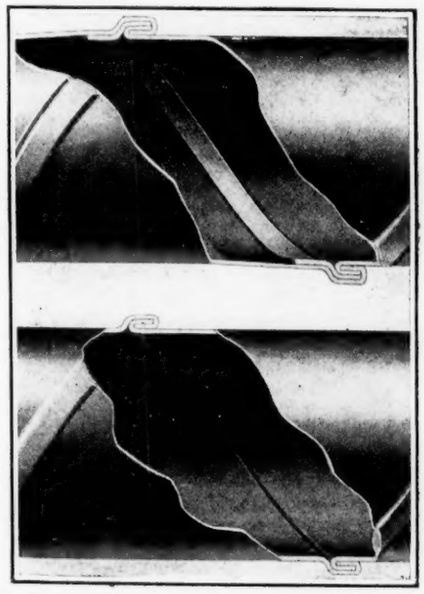


Filter equipped with metal shields

Naylor Spiral Lock-Seam Pipe

The illustration shows the spiral lock-seam pipe, applicable to a number of services in the power plant and industrial fields, manufactured by the Naylor Spiral Pipe Co., 1230 East 92d St., Chicago, Ill. A strip of sheet steel is wound into a spiral shape, but instead of being riveted the edges are automatically flanged and formed into a 4-ply lock seam laid up on the outside of the pipe. This type of seam adds materially to the strength of the pipe and leaves its interior smooth and free from rivet heads or other obstruction.

The upper view in the illustration shows the pipe with a high-carbon steel wearing strip for handling abrasive materials. The type shown in the lower view is for water, gas and other non-abrasive materials. The pipe is formed in a continuous piece and then cut in any desired length up to 40 ft. It is made from No. 16 to No. 10 gage sheets and from 4 to 30 in. in diameter. Plain, galvanized, painted and asphalted pipe may be had.



Spiral pipe with lock-seam joint

World's Greatest Hotel To Have Own Power Plant

Corliss Engines and Both Absorption and Compression Refrigeration Systems, Will Go into Stevens Hotel Plant

THREE thousand outside rooms in a building measuring in plan 402x 173 ft., rising 25 stories above ground and descending four floors below, inclosing 20,000,000 cu.ft. and resting on a site covering 80,000 sq.ft., are the physical data of the new Stevens Hotel, Chicago, which is in course of erection with expectations of being ready to receive guests by March 1, 1927. Of the public appointments a banquet hall

From architect's drawing of the new Stevens Hotel

having seating capacity for 4,000 guests and an exhibition room for conventions containing over 35,000 sq.ft., are features. In addition to the main structure there will be a 12-story service building covering an area of 174x52 ft. and containing a laundry, bakery, carpenter shop, the refrigerating system and other services. The largest power plant ever placed in a hotel will be installed in the sub-basement of the main building.

That it should be an individual power plant was a foregone conclusion, as experience of the same management in the Hotel La Salle had shown the economy of generating electrical energy for power and light and utilizing the exhaust steam to the fullest extent in the other services. With the variety and magnitude of the services required in an institution of this character, the problem was to secure a balance between the supply and the demand for exhaust steam. This has been done effectively by a judicious selection of equipment to be driven electrically and in the auxiliaries provision of both steam and electric drive to give the flexibility needed to maintain a positive heat balance throughout the different seasons of the year. In other words, such services as heating, refrigeration and hot water are to be produced practically as byproducts from the power steam. Just how this is being done will be brought out in the following outline of the plant.

To provide the large quantities of exhaust steam needed for hot water, heating, refrigeration and other services, it was decided to drive the elevators electrically. There will be fourteen passenger elevators of late design with automatic control, ten service elevators, two hydraulic lifts, four dumbwaiters and one 10-ton freight hoist. The connected load for the elevators will total 900 kw.

Heating System

Heating will be effected by a vacuum return line system having a total of 130,000 sq.ft. of direct radiation. For ventilation large quantities of air will be supplied to the building generally and in particular to the restaurants and public rooms. This air will be washed and conditioned, with close regulation of temperature and humidity. During the summer months the air will be cooled by refrigeration. A total of 509,620 cu.ft. per minute of fresh air will be delivered to the building by 19 fans, each provided with tempering and reheating coils, there being a total of 25,000 sq.ft. of such indirect surface for this purpose, all automatically controlled. To exhaust 637,434 cu.ft. of air from the building, 28 exhaust fans will be used. The 47 motors driving the fans and exhausters and the motors on the air washer pumps aggregate 750 hp.

Other electric load will be two of the four house pumps, two duplex, two-stage, belt driven, 560-cu.ft. air compressors, the equipment generally in the laundry and in other departments requiring power. Exclusive of the elevators the total connected load of motor-driven equipment will aggregate 1,600 kw. With 2,000 kw. allotted to the lighting, the total connected load will be 4,500 kw. Owing to its diversity a normal generator load not in excess of 2,000 kw. is anticipated.

Steam Generating Equipment

Direct current at 230 volts for power and 115 volts for lighting will be supplied by a generating capacity of 3,100 kw. made up by five engine-driven generating units, three of 750-kw., one of 500-kw. and one of 350-kw. capacity. This variation in size of unit will give sufficient flexibility and overload capacity to meet all requirements.

In the selection of the units reliability and long life were made the primary requisites, with economy for non-condensing operation the deciding factor. The selection rested with heavy-duty Corliss engines having a speed of 100 r.p.m. The three larger engines are cross-compound machines and the other two simple Corliss engines. Steam at the throttle will average 165 lb. gage and operation will be against a back pressure approximating 2 lb.

To generate steam for all purposes at 175 lb. pressure, seven water-tube boilers will be installed, having an aggregate of 45,350 sq.ft. of surface. They will be equipped with chain grates having a total active area of 1,015 sq.ft. and a steam-jet ash-handling system with remote steam control, so that the operator can open or close the main steam valve while working at any of the ashpits. The stokers will be motor driven from a common lineshaft with steam drive as a reserve. There will be three boiler-feed pumps, two direct-acting, 14x8½x15-in., and one turbine-driven of 350 gal. per min. capacity, and two open type V-notch metering heaters, each having a capacity of 100,000 lb. an hour.

Refrigeration

A refrigerating plant of 500 tons capacity indicates the magnitude of this service. It will consist of two 125-ton exhaust-steam absorption machines and two 125-ton uniflow-engine-driven compressors. Taking steam from the general exhaust system at 2 lb. pressure, the absorption plant will carry the house load consisting of 25 tons of ice daily, the freezing and hardening of 120 gal. of ice cream per hour, the cooling of 70 refrigerators and storage rooms and the cooling of the drinking water for the individual faucets in the 3,000 rooms.

Ordinarily, the compressors will be used for the cooling of 85,000 cu.ft. of air per minute to the public rooms, such as the dining and banquet rooms, the lobby, barber shop, etc. The two types of equipment give a flexible arrangement to meet varying seasonal demands. For example, during the winter months when the heating load is heavy, the compressors may be operated instead of the absorption plant, or one of each type may be used. During the summer months, when air cooling

is needed and the usual refrigerating load is heavy, with the cooling water at high temperature, plans are being made to operate the absorption plant on steam at 10 lb. back pressure. Not wishing to subject the main generating units to this back pressure, an auxiliary exhaust main will be provided and so arranged that the exhaust from the ammonia compressors, the brine and aqua pumps, and of the two steam-driven house service pumps if necessary, may be isolated and supplied to the absorption plant at the 10 lb. pressure. Any excess of steam at this pressure will pass through a back-pressure valve to the main 2-lb. exhaust system, and a shortage may be supplemented by live steam through a reducing valve.

Simultaneously, the exhaust from the generating units, the boiler-feed and the vacuum pumps will be passing to the main exhaust line at 2 lb. back pressure to meet the demands in the hot-water and feed-water heaters and in the laundry. Except for short peak periods of the electric load during the day, it is anticipated that balanced conditions will be maintained. During the eight months of the heating season there should be no waste of exhaust steam, so that exceptional over-all economies for the entire year are to be expected from the new plant.

Holabird and Roche are the architects and engineers for the entire project. J. A. Sutherland, their chief mechanical engineer, and F. A. Byrne, chief electrical engineer, working in conjuction with Walter Bird, of the Stevens Hotel Corporation, are responsible for the design of the plant.

Progress Made in Use of Mercury-Arc Rectifiers

According to the American Institute of Electrical Engineers Committee on Electrical Machinery Report, during the last year the mercury-arc rectifier has been further developed and notable improvements have been made, particularly with regard to the automatic upkeep of the vacuum and to simplifying the control and auxiliary apparatus.

This piece of apparatus would appear to approach the ideal for the rectification of alternating current in that the function is performed without transforming the energy into magnetic and mechanical energy with the attendant losses. The loss affecting the efficiency of the rectifier is the arc drop within the tank and, since the arc drop is approximately constant, the rectifier does not show as high efficiency at rated load as does the rotary converter for large low-voltage capacities. For heavy-duty traction purposes involving voltages above 600, the rectifier has better efficiency characteristics.

American manufacturers are now offering rectifier equipments for railway substations and industrial power uses that may operate in parallel with rotary converter or motor-generator equipments and are arranged for complete automatic operation. Rectifiers are usually supplied with a slightly dropping characteristic, which may be adjusted to match the characteristics of shunt-wound rotary converters operating in parallel. Rectifiers may also be compounded in order to obtain voltage control; however, it must be appreciated that this control will slightly lower the over-all efficiency and power factor of the rectifier unit. Equipment has been developed to include the application of automatic voltage regulators for maintaining constant direct-current voltages.

A peculiar advantage of the rectifier over other types of converters from a commercial point of view is that the rating of a unit is independent of the frequency of the alternating current and within certain limits a given rectifier is suitable for operation at various voltages, the kilowatt capacity being greater the greater the direct-current voltage. While rectifiers have been extensively used in Europe for more than one decade, there are only two commercial installations in America that have been in commercial service for more than one year. A few more were added during the last year, and a large number of equipments are on the books of American manufacturers and will go into service this year.

The voltage limitations of the rectifier are much higher than those of synchronous converters and motor-generator sets, for they are built in capacities as large as 3,000 kw. at 4,000 volts direct current. One 4,000-volt plant has been in successful operation for more than two years on a standard-gage railroad in Europe. These capacities are characterized by high efficiencies. Since the loss is due only to the resistance drop of the arc, the efficiency is inherently higher for the higher voltage ratings. Other advantages that have been claimed are that there is no synchronizing operation and there are no moving parts. The absence of noise and vibration makes the rectifier peculiarly desirable for substations in congested and residential districts where quiet operation is necessary.

English Industrial Plant Uses Pulverized Coal and Coke

By E. Kilburn Scott

The new boiler plant of the Synthetic Ammonia & Nitrates, Ltd., Billingham-on-Tees, England, is designed to burn a pulverized mixture of low-grade bituminous coal and coke breeze. The two fuels are placed in separate bins and are mixed by a special apparatus just before use. If the moisture is less than 8 per cent, the mixture goes directly to the roller mills; if higher, it is passed through steam driers containing a set of rotating trays upon which the coal drops. The grinding is done by two Raymond 6-roller mills, of 6-ton-per-hour capacity. The fineness of grinding depends upon the percentage of coke in the fuel; usually, 85 per cent will pass through a 100-mesh sieve. After grinding, the fuel is carried by two screw conveyors 94 ft. long to bunkers above the boilers.

The boilers are of the John Thompson vertical-tube type, each having 9,000 sq.ft. of heating surface, and when working in combination with the water tubes of the furnace wall and the water screens, the evaporation can be 87,000 lb. per hour from and at 212 deg. F. The final steam temperature is 650 deg. F., and the pressure 275 lb. per sq.in. Each boiler has a standard Lopulco combustion chamber, measuring 24½ ft. by 16½ ft. and 24 ft. high, from the flat suspended arch to the top of the ash hopper.

The top of the combustion chamber has a flat suspended arch in which there are five fish-tail burners set at intervals of about 3 ft. These deliver the fuel downward and the flames meet currents of preheated secondary air, which enters the chamber at right angles to the direction of the flame. After having traveled about 15 ft., the velocity is so reduced that the draft from the chimney is sufficient to cause the flames to turn and pass upward to the tubes of the boiler, which are immediately above.

The 4-in. water-screen tubes are set at 14-in. pitch, so that there is a distance of about 10 in. between them. The ends of the tubes are connected to headers which in turn connect to the boiler, and they are, therefore, a part of the boiler system. As similar 4-in. diameter tubes are set in the back wall and in each side wall, the flames are almost surrounded.

Under each pulverized-fuel bunker there are five feeder screws, coupled to an electric motor in such a way that either two or three screws or all five may be operated at the same time. Powdered fuel drops on these screws by gravity, and is forced forward at a speed to suit the load on the boiler, the possible speed variation being about 3 to 1.

At the delivery end of each screw some air is introduced which has already been slightly preheated by passing through the hollow wall of the ash hopper, and this air serves to prevent jamming. It also carries the fuel down to the burner and helps combustion just at the moment when the fuel issues from the burner nozzle.

Supplies of powdered fuel and air are accurately adjusted to the output of steam, by means of a Bailey boiler meter, on the dial of which the synchronizing of red and blue lines shows the usual CO_2 recorders and automatic temperature gages.

It is significant that the whole boiler house is in charge of a trained chemist who has engineers under him.

Each boiler has an air preheater of the plate type, having 74 elements 11 ft. long, which expose a surface of 6,130 sq.ft. The elements of the air heater are so arranged that the lines of entry and exit of both gas and air are such as to avoid eddies, the gas passing through in straight lines and the air follows a curved but easy path. All joints are welded so that there is no leakage, and this is important because the indirect benefit of air heating, apart from the heat units actually returned to furnace may be neutralized by the presence of flue gas in the air.

Each boiler is fitted with a Foster economizer which measures 14½ ft. long, 5 ft. wide and 7 ft. high, and as it is located behind the boiler just above the air heater, the flue gases flow through a short flue into the economizer and thence to the air heaters and the induced-draft fan.

News in the Field of Power

Finch Report to Commission on St. Lawrence Power Problem Urges Private Leasing

Stands Out for Immediate Action on Development—Finds Revenue of Million at Outset—Future Market For All Power Seen—Provisions of Leases

RECOMMENDING the adoption without further delay of a practical development of the water power possibilities of the St. Lawrence River on June 29 Roy C. Finch, New York State Engineer, on June 29 presented to the State Water Power Commission, a report on the applications of power corporations for authority to develop and sell the St. Lawrence Power.

Mr. Finch as the *New York Herald Tribune* reports, makes no definite recommendation as to which one of several plans suggested would be best to adopt, except to suggest that from the standpoint of New York State a single-stage rather than a two-stage development probably would be more desirable.

As to the probable industrial expansion that would follow, Mr. Finch said that statistics show "that in New England every dollar expended in the building of hydro-electric power plants has been matched by the expenditure of $8 for industries.

"If New York State in the development of the St. Lawrence River experienced the same stimulation to industrial growth as New England from its water power, the people could look forward to the investment of almost $1,000,000,000 in industrial enterprises." he said. "The value to the state from such an industrial expansion is almost beyond comprehension."

One Million Revenue

Estimating $2.50 a year per horsepower as a reasonable license fee to be paid to the Federal and state treasuries by the company developing the power, Mr. Finch contends that this would mean more than $1,000,000 a year in revenue to New York State at the outset and would be increased from year to year as a market is found for all the power that can be produced. The development would be approximately 2,500,000 hp., one-half of which would belong to Canada, with the other half on the American side of the international boundary.

The engineer emphasized that the state at any time can take over the entire development and perhaps at a figure less than had the state itself financed and constructed the project. The engineer also declared that this provision, coupled with that relating to the immediate execution and filing of a quit claim deed transferring to the people without cost all properties at the expiration of the license period, should eliminate any fear that the development of this power under a lease is a gift to any concern or corporation.

Future Market For All Power

It is extremely doubtful, Mr. Finch said, if immediately on the completion of such a mammoth plant a market would be found for all the power that it could produce, especially during certain night hours. What the future has in store as to the use of electricity is problematical, but it is reasonable to suppose that some time there will be a sale for all the electrical energy a plant may produce day and night, 365 days in the year.

"With proper safeguards to protect this state, the decision as to a single or two-stage development is not vital, but the provisions in a license are of the utmost importance," said Mr Finch. "Every precaution must be set up not only to preserve the rights of the people in the ownership and control of this natural resource, but to insure to them the benefits to which they are justly entitled."

"But," the engineer said, "the state should not insist upon requirements or commitments on the part of the licensee that will deprive capital of initiative and a fair and proper return on an investment, which involves greater risk and calls for more engineering skill, financial assistance and civic determination than has ever been exacted in any public or private proposal."

The principal provisions to be included in leases for the protection of the state recommended by Mr. Finch follow:

1. The license period not to exceed fifty years and a definite term of not more than three years within which the licenses to proceed must obtain consents from other governmental agencies. Failure to obtain consents within that time would exact a renewal of the license by the state.

2. The license fee to be payable on completion of the project, but not later than five years from the date when full authority to begin construction is granted.

3. Inspection by the state during construction to make certain that the project is built in accordance with the conditions of the license and to make ascertainable the actual cost. The expense of such action of the state to be paid by the licensee.

4. The licensee to post a faithful performance bond of $10,000,000 to carry out construction in accordance with the terms of the license.

5. On the final completion of the project, the state reserves the right to purchase at cost plus 15 per cent, or at any time during the license period on five years' notice at cost, less amount set aside for amortization, plus 15 per cent.

6. Guarantee that transmission lines will be provided by the licensee to insure distribution of St. Lawrence current in every section of the State of New York.

7. Full authority by the Public Service Commision to fix rates at which current is sold, municipalities to be given preference.

8. The license fee to be adjusted at the end of five years and thereafter at ten-year periods.

9. At the end of fifty years, if the state has not taken over the project, all property, dams, power houses, machinery, lands and riparian rights on this side of the international boundary revert to the people without cost or expense, a quit claim deed to be immediately executed and filed to carry this into effect.

Plant to Employ Steam at 825 Lb. Pressure

The Solvay Process Co. of Syracuse is installing a new power plant in which steam at 825 lb. gage will be furnished by two combustion steam generators, complete with air heaters and unit pulverizers.

Two 5,000-kw. turbo-generators, operating at a throttle pressure of 725 lb. (700 deg. total temperature) will exhaust against a back pressure of 165 lb. gage for process work. Under these conditions the exhaust steam will be superheated.

New Ontario Commerce Body to Deputize Hydro Power

In the establishment and activity of the Eastern Ontario Chamber of Commerce, inaugurated June 22 at Belleville, Ont., the power industry in that province will play an active part, according to reports.

The Hydro Power Commission of Ontario will later be deputized respecting power for eastern Ontario. A request will be made that sufficient power for present and prospective requirements be afforded, and at the same rate as provided western Ontario. Deseronto fathered a resolution to this effect.

Boiler Explosion Kills Fireman

Circumferential Crack Develops Undetected in Head of Drum Due to Breathing Action, in Spite of Periodic Inspection

ON THE morning of June 15 at 7:20 o'clock, a water-tube boiler of the box-header type exploded at the plant of the Albert David Chemical Co., Chicago Heights, Ill., killing the fireman and demolishing the building in which it was located. The property damage approximates $25,000. The accident happened just after the day fireman had thrown in a fire and was pushing the wheelbarrow away. At this juncture the rear head let go, the ½-in. metal in the head having ruptured all the way around, as the result of a crack in the heel of the flange. The circular piece from the head demolished the building wall some 20 ft. distant and the entire boiler was projected in the opposite direction 65 ft. from the original setting, crossing some railway tracks in its flight. The fireman was directly in its path and was found buried in the débris after the accident.

Pressure Far Below Capacity

The boiler had 1,500 sq.ft. of steam-making surface, eighty-seven 3½-in. tubes 18 ft. long and a drum 48 in. diameter. It was built in 1903 and had been in its present service since 1920. Insurance was carried and it had been inspected regularly. Although a pressure of 125 lb. had been allowed, it was the practice to carry only 20 to 40 lb.

Breathing Caused Rupture

Observation of the head after the explosion showed that an old crack about halfway through the metal, and in places slightly deeper, had existed all the way around the head at the heel of the flange. The crack had finally developed to a point where the remaining metal could not withstand the pressure, and the complete rupture occurred. This condition was clearly the result of breathing action of the head.

It is a well-known fact that if a head forms a true hemisphere, there can be no breathing action and no tendency to a change in shape. As the shape of the head flattens, the breathing action develops and increases as the head tends to approach a flat surface. Boilers built a few years ago in general had less dish than is required today. The stresses set up by this breathing action are concentrated in the heel of the flange, so that if a crack does develop, it is usually in this location.

Crack Hard to Find

If the boiler water contains scale-forming matter, and it usually does, scale will form over the crack, so that it is sometimes difficult to detect from a visual inspection. If, after the crack has started, the pressure is lowered, as in the present case, the breathing action may be sufficient to continue the development of the crack, but the movement may not be enough to make it apparent on the surface; that is, to disturb the coating of scale. One would suppose, however, that a crack of this extent would be revealed by a hammer test.

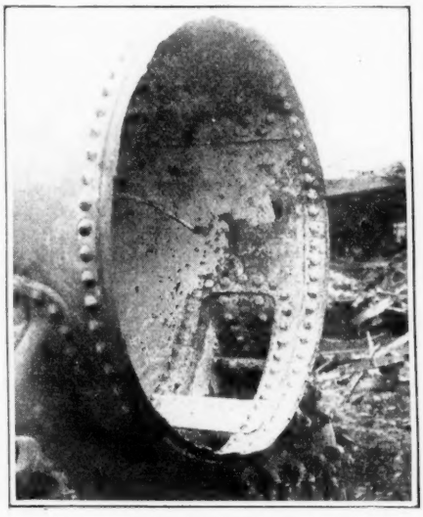


Fig. 2—End of drum from which head tore loose

Fig. 1—View taken near the original setting showing the path taken by the boiler

Exact Pressure Unknown

Just what pressure the boiler carried at the time of the accident is rather indefinite as the pressure gage could not be found and the safety valve had been broken and could not be tested. Upon leaving at 6 o'clock, the night fireman had looked at the gage and stated that it had shown 20 lb. pressure. The explosion occurred more than an hour later.

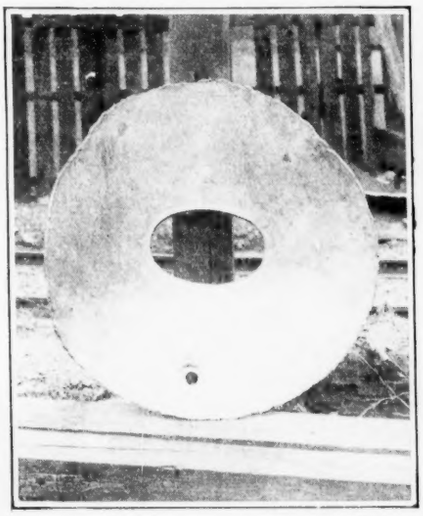


Fig. 3—Portion of rear head separated from drum

Huge Gatineau Power Service Scheduled

Final arrangements have been completed between the Ontario Hydro Electric Power Commission and the Gatineau Power Co., subsidiary of the International Paper Co., whereby the latter will furnish the former with approximately 250,000 hp. of electrical energy from its huge hydro electric developments on the Gatineau River in the province of Quebec. The contracts were signed a few days ago.

The immediate program of the Gatineau Power Co. will add materially to Canada's developed power resources, as well as constitute a great step forward in the International Paper Co.'s plans for profitable utilization of its undeveloped properties. The total initial installation on the Gatineau will be from 350,000 to 400,000 hp. The company's record is believed to be unique in the annals of power corporations in that between 85 per cent and 90 per cent of its output is already contracted for.

Three powers will be developed—the first at Chelsea, nine miles north of Ottawa; the second at Farmers Rapids, about a mile below Chelsea and the third at Paugan Falls, about 30 miles north of Ottawa.

Unprecedented Unit Planned for Hell Gate Plant

A power unit of gigantic size for the Hell Gate station in Bronx Borough, New York City, of the United Electric Light & Power Co. has been recently purchased, according to announcement issued by the company. Operation is expected to begin during the summer of 1928.

The order has been placed with the recently formed American Brown Boveri Electric Corp. and its installation will be made under the supervision of Thomas E. Murray, Inc., as consulting engineers. The unit has a continuous-load capacity rating of 160,000 kw. at 85 per cent power factor, or 188,250 kva., and will generate current at 13,800 volts, 60 cycles.

This is the eighth unit to be installed in the Hell Gate station, which is operated as part of the Edison-United system, and will increase the continuous operating capacity of the station to 445,000 kw. It will be a compound unit consisting of a single-flow, high-pressure element operating at 1,800 r.p.m. and a double-flow, low-pressure element at 1,200 r.p.m. There will be an exciter directly connected to each generator. The generators will require 264,500 cu.ft. of cooling air furnished by external blowers.

The steam turbine will be of reaction type throughout. It is designed to occupy the same space allotted to each of the other units, and its installation will complete the equipment of the present station building. It is to operate under the present steam conditions of the station, 265 lb. pressure at the turbine throttle, with 200 deg. superheat, and is designed for bleeding for feed-water heating. The high-pressure turbine portion is designed to be capable also of utilizing steam at a maximum temperature of 750 deg. F. The unit will weigh approximately 2,800,000 lb., the heaviest piece for erection weighing 330,000 lb.

The unit will be assembled and shipped from Camden, N. J., where the American Brown Boveri Corp. has its main construction plant.

Finland Contracts for New Power Plant

The Imatra Water Power Board of the Finnish government announces that the contracts offered by various firms for the transmission lines of the Imatra power plant have been accepted by the government on certain conditions, according to a report to the Department of Commerce from Assistant Trade Commissioner Emil Kekick at Helsingfors.

The Finska Kabelfabriken A-B., a local concern, was awarded the conductors, which are to be made from American copper, for the Imatra-Helsingfors-Abo line. On the small Imatra-Viborg section the conductors will be aluminum-steel, to be furnished by the Swedish concern, A-B Svenska Metallverken.

Steel ground wire will be furnished by Gutehoffnungshutte A-G. The contract for the insulators has been divided among an American company, the German firm Hermedorf - Schomburg - Isolatoren g.m.b.h., and Brown Boveri & Co. Telephone equipment will be delivered by Deutsche Telephonwerke.

Orders for transmission-line towers were divided between four domestic manufacturers: The Finnish State Railways, Maskin och Brobyggnads A-B., Chrichton Vulcan and Finska Bultfabriken. The construction of the concrete foundations has been going on for some time, the greater part of the work on the line Imatra-Kikia-Helsingfors now being furnished.

Brown Coal Moisture Acute Problem for Australia

Confronted with serious difficulties in the burning of brown coal in the generation of electric power, the Electricity Commission of Victoria, Australia, is studying ways and methods of reducing the high percentage of moisture carried by this "young" variety of coal, according to a report on the progress and affairs of the commission made by Willits H. Sawyer, president of the East St. Louis & Suburban Railway Co., to the Lieutenant-Governor of Victoria.

In commenting on the Yallourn Steam Power Station, Mr. Sawyer said that the boiler plant was designed to burn brown coal with 48 per cent moisture, and that, if this had not been exceeded, the capacity of the boiler room expected would have been realized. But the development of a new source of brown deposit, which was expected to yield coal with less than 50 per cent moisture has in reality developed a product with 65 per cent moisture. Moreover, fuel driers installed on three boilers have not worked out satisfactorily, as the plant, as it stands, in both equipment and methods of operation, is not adequate for fuel of this high degree of moisture. This plant was described in Power for March 9, 1926, page 373.

Practical tests are recommended to determine the economic merits of drying coal from 65 per cent moisture to 15; and, in view of the scarcity of Australian engineers familiar with large power-plant design and operation, and with the mining and burning of such moist fuel, the commission's practice of sending engineers abroad is strongly advocated. Mr. Sawyer believes that several members of the commission staff should be sent abroad at once to study the latest designs of large power plants.

Veteran Company Celebrates Fiftieth Anniversary

E. H. Rollins & Sons celebrated the fiftieth anniversary of its founding June 16. E. W. Rollins, who established the firm when the nation was observing its first centennial, is still chairman of the board.

Rollins & Sons financed the second alternating-current electric-light plant in the United States. This was built at Denver in 1889 after George Westinghouse had built a similar one at Pittsburgh. The firm also financed a transmission line from Colgate to San Francisco, the first to be erected in California.

New Motor Fuel Submitted to Bureau of Standards

A new motor fuel which will, according to its sponsors, lessen operating costs for the public by increasing mileage, do away with carbon troubles, eliminate "knocking" in cylinders, and above all help to conserve the country's supply of crude oil, was announced in Washington, June 28, when Charles P. Tolman, chairman of the research committee of the Petroleum Conversion Corp. of New York, submitted a report with samples of the new fuel to the Bureau of Standards for analysis and test.

Request was made that the government bureau make a thorough examination of the data and material filed, and at the same time Mr. Tolman, widely known as a consulting engineer, expressed the hope that the bureau might see fit to suggest an appropriate classification for the fuel since it is in no sense gasoline.

Michigan Power Concerns Plan Merger

An application for permission to consolidate several electric light and power companies serving counties in the northern part of the lower peninsula of Michigan was filed with the state public utilities' commission recently. The proposed merger would join the Michigan United Light & Power Co., the White River Power Co., the Boyne City Electric Co., the Boyne City River Power Co., the Michigan Public Service Co., the Elk Electric Co. and the Grayling Electric Co.

The proposed name of the consolidation is the Michigan United Light & Power Co. Mortgage bonds in the amount of $1,250,000 and 150,000 shares of no par value common stock would be issued. Stockholders in the companies would trade their holdings for stock in the consolidated concern.

The main offices of the new company would be in Ludington and the counties served would be Mason, Oceana, Lake, Manistee, Muskegon, Wexford, Benzie, Grand Traverse, Kalkaska, Crawford, Antrim, Otsego, Charlevoix, Emmet and Cheboygan. The proposed capitalization is $2,000,000.

Minnesota Firm Buys Power Properties in Northwest

The W. B. Foshay Co., of Minneapolis, Minn., has expanded its holdings in the Pacific northwest by entering into a contract to purchase electric light and power properties in Oregon and Washington from the West Coast Power Co., which is owned and operated by Cammack & Co., of Chicago.

According to announcement of the Foshay firm, the new properties will be consolidated August 1, with the holdings of the People's Light & Power Corp., the operating company for the Foshay interests. Addition of the Washington and Oregon utilities will increase the value of the People's Light & Power Co. holdings to more than $8,000,000 while gross earnings will approximate $1,000,000 a year.

Personal Mention

D. D. Gross has been recently appointed chief engineer of the Denver Water Co., Denver, Col.

H. N. Carlson, formerly of the Massachusetts Institute of Technology and Wentworth Institute, is now associated with the R. H. Baker Co., Inc., Cambridge, Mass., as engineer of construction and design.

H. M. Atherton, formerly with the Illinois Power & Light Co. at Peoria, Ill., is now with the Tennessee Coal, Iron & Railroad Co., Birmingham, Ala., at the Ensley Works, engaged on power-plant design.

Nathan A. Bowers, Pacific Coast Editor of *Engineering News-Record* has received the degree of Doctor of Philosophy from Stanford University. As part of the requirements, Mr. Bowers submitted a thesis on "Engineering Failures in the Water Power Field."

Major Glen E. Edgerton, chief engineer of the Federal Power Commission, has been designated to represent that body at the Tri-Annual Congress of the Permanent International Association of Navigation Congresses, which is to meet in Cairo, Egypt, in December.

Henry G. Wolfe has resigned as assistant mechanical engineer with Thomas E. Murray, Inc., of New York City, and has opened an office in New York City as consulting engineer. He will co-operate with David Moffat Myers, 347 Fifth Avenue, upon industrial power, boiler tests and like problems.

R. W. Wieseman, of the alternating engineering department of the General Electric Co. at Schenectady, has been awarded the grand prize by the American Institute of Electrical Engineers for the best paper presented before any section of the institute during the year. The award was made at the annual convention of the organization at White Sulphur Springs, W. Va., in June, and was for the paper on the subject of "Two Speed Salient Pole Synchronous Motor."

Business Notes

The Gifford-Wood Co., manufacturer of elevating and conveying machinery for power and industrial plants, announces the opening of its office in San Francisco at 1274 Folsom Street.

The Buffalo Fuse Corp., manufacturer of Pierce Renewable Fuses, 752-756 Main St., Buffalo, N. Y., announces the opening of a new office at 51 Barclay St., New York City, which is in charge of the Ingham-Gillingham Corporation.

The Garlock Packing Co., manufacturer of Quality Controlled Mechanical Packings, whose general offices and factories are at Palmyra, New York, announces the opening of a new branch sales office and warehouse at 805 Washington Ave., Houston, Texas.

Trade Catalogs

Blower Systems—Kirk & Blum Manufacturing Co., pneumatic engineers, Cincinnati, Ohio. Illustrated booklet on blower systems for industrial uses, such as the handling of acid fumes and gases, abrasive dust, wood shavings, etc. Many installations of various types are depicted.

Coming Conventions

National Association of Stationary Engineers. F. W. Raven, 417 South Dearborn St., Chicago, Ill. Convention at Atlantic City, begins Sept. 14. Erroneously announced as Sept. 6-11. Annual conventions and exhibitions of state associations are scheduled for the following dates:

Wisconsin State Association, R. L. Scott, Eau Claire, Wis. Convention at Milwaukee, Aug. 3-6; **Minnesota State Association,** C. A. Nelson, 800 22nd Ave., N. E. Minneapolis, Minn. Convention at Rochester, Minn., Aug. 4-6; **New Jersey State Association,** S. G. Dalrymple, 111 Hutton St., Jersey City, Convention at Atlantic City, Sept. 12; **Pennsylvania State Association,** Frank J. McCarron, 3647 North 11th St., Philadelphia, Convention at Philadelphia, Sept. 12-13.

New York State Association. Wilmer T. Meinzer, 3626-215 Place, Bayside, Long Island, N. Y. Postponed from June 11 to 12, at Troy, N. Y., to Sept. 12-13 at Atlantic City, N. J.

Universal Craftsmen Council of Engineers. 24th convention and exhibit Milwaukee Auditorium, Milwaukee, Aug. 3-7.

High Pressure Steam Traps—W. H. Nicholson & Co., manufacturers of machinery and steam specialties, Wilkes-Barre, Pa. Bulletin No. 626 is devoted to the super-pressure type traps for pressures from 2 to 200 lb. constructed of cast iron, and higher pressure traps of cast steel for 2 to 400 lb. Bulletin No. 526 describes the tank type trap for all service and pressures from 2 to 600 lb.

Concrete for Insulations — Celite Products Co., Los Angeles, Calif. New bulletin published on Sil-O-Cel C-3 and Sil-O-Cel C-3 Concrete. The former is a semi-refractory insulating product made from mineral Celite, calcined in order that it may withstand temperatures in excess of 2,000 deg. F. without shrinkage. Sil-O-Cel C-3 Concrete contains 20 per cent by volume of portland cement and weighs 60 lb. per cubic foot when rammed into place and dried.

Automatic Pumping—Barrett, Haentjens & Co., Hazleton, Pa. A new twenty-four page booklet, bulletin No. 400a and other bulletins have been issued by this company describing the automatic operation of centrifugal pumps, but the latest edition differs from the others in that the subject is treated from a purely technical viewpoint and several new methods of making centrifugal pumps automatic are described. Copies of this booklet can be secured by writing Barrett, Haentjens & Co., and asking for Bulletin 400a.

Condensers — Wheeler Condenser & Engineering Co., 149 Broadway, New York City. Catalog describes and illustrates a new tube-plate layout which utilizes the kinetic of the steam leaving the turbine blades to secure steam penetration in the condenser and sweep out the non-condensable gases. The fields of single- and two-pass condensers, their care and upkeep, and the factors controlling corrosion of tubes, and the application and operation of hotwell and circulating pumps, are considered. Geo. H. Gibson Co., 100 Gold St., New York City, is the distributor of this product of the Wheeler Condenser & Engineering Co. A previous notice of this catalog erroneously carried the name of the distributor in place of that of the manufacturer. Circulating pump characteristics are discussed.

Fuel Prices

COAL

The following table shows the trend of the spot steam market in various coals, f.o.b. mines; mine run except Pittsburgh gas slack:

Bituminous Net Tons	Market Quoting	June 28 1926
Pool 1	New York	$2.50@$2.75
Smokeless	Boston	1.70
Clearfield	Boston	1.65@ 2.00
Somerset	Boston	1.75@ 2.10
Kanawha	Columbus	1.40@ 1.75
Hocking	Columbus	1.40@ 1.70
Pittsburgh	Pittsburgh	1.60@ 1.90
Pittsburgh gas slack	Pittsburgh	1.20@ 1.30
Franklin, Ill.	Chicago	2.25
Central, Ill.	Chicago	2.00@ 2.15
Ind. 4th Vein	Chicago	2.10@ 2.25
West Ky.	Louisville	1.10@ 1.40
S. E. Ky.	Louisville	1.35@ 1.65
Big Seam	Birmingham	1.75@ 2.00
Anthracite Gross Tons		
Buckwheat No. 1.	New York	1.50@ 3.50
Buckwheat No. 1.	Philadelphia	2.15@ 2.75
Birdseye	New York	1.20@ 2.00

FUEL OIL

New York—July 1, light oil, tank-car lots; 28@34 deg. Baumé, 6c. per gal.; 36@40 deg., 6¾c. per gal. f.o.b. Bayonne, N. J.

St. Louis—June 22, tank-car lots, f.o.b. St. Louis; 24@26 deg., $2.05 per bbl.; 26@28 deg., $2.10 per bbl.; 28@30 deg., $2.15 per bbl.; 30@32 deg., $2.20 per bbl.; 32@36 deg., gas oil, 5.8c. per gal.; 38@40 deg., 6.5c. per gal.

Pittsburgh—June 29, f.o.b. local refinery; 30@34 deg., fuel oil, 6¾c. per gal.; 36@40 deg., fuel oil, 7½c. per gal.

Dallas—June 26, f.o.b. local refinery 26@30 deg., $1.70 per bbl.

Philadelphia—June 23, 27@30 deg., $2.62½@$2.68½ per bbl.; 18@22 deg., $1.93@$1.99; 13@19 deg., $1.75@$1.81 per bbl.

Cincinnati — June 22, tank-car lots f.o.b. local refinery, 24@26 deg. Baumé, 6½c. per gal.; 26@28 deg., 6⅝c. per gal.; 28@32 deg., 7c. per gal.

Chicago—June 28, tank-car lots f.o.b. Oklahoma, freight to Chicago, 92c. per bbl.; 24@26 deg., $1.25 per bbl.; 26@30 deg., $1.30; 30@32 deg., $1.45.

Boston—June 28, tank-car lots, f.o.b. 12@14 deg. Baumé, 4.43c. per gal.; 28@32 deg., 5.8c. per gal.

New Plant Construction

Calif., Los Angeles—Lloyd & Casler Inc., 315 East 8th St., plans the construction of a 12 story loft building including gas heating system,, electric elevators, etc.; at 8th and Santee Sts. Estimated cost $500,000. W. D. Lee, 709 Textile Center Bldg., is architect. Work will be done by owner's forces.

Calif., Los Angeles—Security Title Bldg. Inc., 303 W. 1st. St., awarded contract for the construction of a 13 story office and stores building at 6th St. and Grand Ave. to Edwards, Wildey & Dixon Co., Edwards & Wildey Bldg. Estimated cost $1,350,000.

Calif., San Mateo—B. Getz, awarded contract for the construction of first unit to 8 story hotel to A. Johnson, Call Bldg., San Francisco. Estimated cost $265,000. Total estimated cost $750,000 to $1,000,000.

Calif., San Francisco—Club Farallon, J. B. Detwiler, Pres., Shreve Bldg., awarded contract for the construction of a 6 story hotel and club building on Harding Blvd. to Lindgren-Swinerton Inc., 225 Bush St. $1,175,000.

Calif., San Francisco—Syndicate awarded contract for the construction of a 15 story hotel at Jones and California Sts. to Chaill Bros., 55 New Montgomery St. Estimated cost $1,000,000.

Calif., Yuba City—Preparing specifications for 12 in. pump, for municipal waterworks. E. Von Geldern is city engineer.

Conn., Westport—Westport Sanitarium, F. D. Ruland, awarded contract for the construction 1 story, boiler house, to M. J. Riordan, Hoyt St., Norwalk. Estimated cost $50,000.

Ga., Waycross—Lott Investment Co., is having plans prepared for the construction of a hotel. Estimated cost $500,000. G. Lloyd Preacher & Co., 1204 Wynne Bldg., Atlanta, are architects.

Ill., Chicago—F. Brons, 1021 North Dearborn St., is having plans prepared for the construction of a 15 story hotel at 1214-1218 North State St. Estimated cost $1,500,000. Oldefest & Williams, 605 North Michigan Ave., are architects.

Ill., Chicago—Robert S. DeGoyler & Associates, 307 North Michigan Ave., is having plans prepared for the construction of a 17 story apartment at State and Goethe Sts. Estimated cost $2,500,000.

Ill., Chicago—M. A. Howell, 4911 Winthrop Ave., awarded contract for the construction of a 29 story hotel at Chestnut and Seneca Sts., to Fitzgerald Construction Co., 105 West Monroe St. Estimated cost $2,000,000.

Ill., Chicago—Lowenberg & Lowenberg, 141 West Monroe St., Archits., are receiving bids for the construction of a 12 story apartment at Sheridan Rd. and Surf St. for Park Lane Building Corp. Estimated cost $5,000,000.

Ill., Chicago—Oldefest & Williams, 605 North Michigan Ave., Archts., will soon receive bids for the construction of a 16 story apartment at 211 East Delaware Pl. for A. W. & I. E. Sommers, 195 East Chestnut St. Estimated cost $750,000.

Ill., Chicago—Syndicate, c/o Hooper & Janisch, 879 North State St., Archts., is having plans prepared for the construction of a 12 and 15 story apartment at 529 Cornelia Ave. Estimated cost $750,000. F. A. Randall, 160 North La Salle St., is engineer.

Ill., Chicago—M. Thorek, 850 Irving Park Blvd., is having plans prepared for the construction of a 12 story apartment at 3918-3924 Lake Shore Drive. Estimated cost $1,000,000. Roy E. France & Co., 155 North Clark St., is architect.

Ill., Highland—City soon takes bids improving power plant, including generating unit either one 600 kw. or two 300 kw. condensing apparatus, coal handling equipment, etc. $50,000. W. A. Fuller Co., 1917 Railway Exchange, St. Louis, Mo., is engr.

Ia., Iowa City—State University, W. H. Gemmill, Secy. State Bd. of Education, awarded contract for the construction of a 7 story hospital to J. & W. A. Elliott, 905 Lumber Exchange Bldg., Minneapolis, Minn. $1,343,739.

Kan., Kansas City—Federal Reserve Life Insurance Co., Federal Reserve Life Bldg., plans the construction of a 20 story office building. Estimated cost $1,000,000.

Mass., Boston—Paul Revere Hotel Corp., J. R. Jackson, Pres., 82 Devonshire St., is having revised plans prepared for the construction of a 16 story hotel at Stuart, Carver and Warrenton Sts. Estimated cost $1,000,000. T. M. James Co., 3 Park St., is architect.

Miss., Columbia—Polar Ice Co. and Mississippi Power Co., plans the construction of a power plant and ice factory to replace fire loss. Estimated cost $60,000.

Miss., Heidelberg—City State Investment Co., Bay Springs, plans to install electric light and water works plant here, to supply towns of Stofford Springs, Vosburg, and Sandersville.

Miss., Laurel—Wallace B. Rogers, et al, c/o Eastman, Gardiner & Co., is having preliminary plans prepared for the construction of a hotel. Estimated cost $2,000,000. Otis & Fuller, 6 North Michigan Ave., Chicago, Ill., and L. W. Duffee, Norman Bldg., Laurel, Miss.; are architects.

Miss., Pass Christian—M. Eiseman, et al, Union Indemnity Bldg., New Orleans, La., is having preliminary plans prepared for the construction of a hotel. Estimated cost $1,500,000.

Mo., Charleston—C. L. Josly, Mayor, will receive bids until July 19, for constructing waterworks improvements, including 2 motor driven deep well pumps, 1 booster pump, etc. F. L. Wilcox, Chemical Bldg., St. Louis is consulting engineer.

Mo., Clayton—Hanley Road Realty Co., c/o B. M. Nevins, 821 Belt Ave., St. Louis, plans the construction of a 3 story apartment including electrical refrigeration and oil burner heating systems, swimming pool, etc. on Hanley Rd. here. Estimated cost $1,000,000.

Mo., Kansas City—Knickerbocker Hotel Co., G. P. Graves, Chicago, Ill., Archt., is having plans prepared for the construction of a 12 story hotel at 3623 Broadway. Estimated cost $1,600,000. Cook & White, 306 Mutual Bldg., are engineers.

Mo., Kansas City—McCanles Building Co., Victor Bldg., plans the construction of two 7 story hotel buildings on Main St. Estimated cost $500,000 each. Work will be done by owner's forces.

Mo., St. Louis—Bd. Public Service, 208 City Hall, will receive bids until July 27, 4 forced draft chain grate stokers for boiler room at waterworks plant at Howards Bend. Estimated cost $35,000.

Mo., St. Louis—W. E. Harral, 5920 Julian Ave., plans the construction of a 6 story apartment at Delmar St. and Belt Ave. Estimated cost $500,000.

Neb. Lincoln—Realty Syndicate, W. E. Sharp, Pres., Terminal Bldg., is having plans prepared for the construction of a 15 story office and stores building. Estimated cost $1,200,000. J. G. McArthur, Keeline Bldg., Omaha, is architect.

N. Y., New York—Six Hundred Sixty Park Ave. Corp., c/o York & Sawyer, 100 East 42nd St., Archts., awarded contract for the construction of an apartment at 67th St. and Park Ave. to Starrett Bros. 292 Madison Ave. Estimated cost $650,000

N. Y., New York—South Central Park Corp., J. H. Davol, Jr., Pres., c/o Caughey & Evans, 29 West 34th St., Archts., is having plans prepared for the construction of a 39 story hotel and office building at 150 West 59th St. Estimated cost $3,500,000.

N. Y., White Plains—H. Panchey, Gramatan Hotel, Bronxville, awarded contract for the construction of a hotel on Fisher Ave. here to Dwight P. Robinson & Co. Inc., 125 East 46th St. Estimated cost $1,500,000.

N. C., Durham—Liggett & Myers Tobacco Co. will soon receive bids for the construction of power plant here. Estimated cost $200,000.

N. C., Waterville—Pigeon River Power Co., 71 Broadway, New York City plans constructing power development, at mouth Cataloochee Creek near here, including power house, 25,000 kw., 13,200 v., 3 ph., 60 cycle, generator connected with 35,000 hp. hydraulic turbine, with 780 ft. normal head.

O., Akron—Bd. County Comrs. will receive bids until July 12, for alterations to heating plant, at Childrens Home, including steam boiler, 2 circular pumps, etc. G. S. Rider Co., Century Bldg., Cleveland, is engineer and architect.

Okla., Seminole—City having plans prepared for construction extensions to waterworks, including deep well pumps, etc. Estimated cost $60,000. Gant-Baker Co., 1116 West Main St., Oklahoma City, is engineer.

Okla., Oklahoma City—R. Perine, 130½ West First St., awarded contract for the construction of a 12 story office building on First St. to Manhattan Court Co., Muskogee. Estimated cost $1,600,000.

Pa., Philadelphia—Chanceller Realty Co., c/o R. B. Bencker, Bellvue Court Bldg., Archt., plans the construction of a 15 story office building at 1420-1422 Walnut St. Estimated cost $1,000,000.

Pa., Philadelphia—J. P. Eckert, Commercial Trust Bldg., will soon award contract for the construction of a 3 story apartment at 5427 Wayne Ave. Estimated cost $500,000. W. F. B. Koelle, Otis Bldg., is architect.

Pa., Philadelphia — Warren Apartment Corp., c/o Lippincott & Schaef, 11 South 16th St., Archts., awarded contract for the construction of a 10 story apartment at 63rd, Columbia and Lebanon Sts. to R. P. Whitty Co., Union Trust Bldg., Washington, D. C. Estimated cost $750,000.

Tex., Amarillo—C. T. Herring, plans the construction of a 12 story hotel at 3rd and Pierce Sts. Estimated cost $1,000,000. Architect not selected. E. O. Thompson, is lessee.

Tex., Ft. Worth—J. H. Jones & Associates, Houston, are having plans prepared for the construction of a 22 story hotel and theatre building at 7th and Taylor Sts. here. Estimated cost $2,000,000. A. C. Finn, Bankers Mortgage Bldg., Houston and W. C. Hedrick, First National Bank Bldg., Ft. Worth, are architects.

Tex., Mineral Wells—Crazy Well Hotel Co,. c/o C. P. Collins, Pres., Dallas, is having plans prepared for the construction of a 6 story hotel. Estimated cost $1,000,000. Lang & Witchell, and Withers & Morrell, Dallas, are architects.

Tex., Seguin—Guadalupe County is receiving bids constructing water power projects on Guadalupa River, between here and New Braunfels. Estimated cost $2,500,000. Address A. J. Wirtz, Seguin.

Va., Richmond— R. K. Compton, Dir. Public Works, will receive bids about July 12, for the construction of pump house, to prevent overflow from Shockoe Creek. Estimated cost $50,000.

Wis., Mauston—R. H. Davis, will build hydro electric power plant, on Lemonweir River, here by day labor. Estimated cost $40,000. L. A. DeGuere, Mead-Witter Blk., Wisconsin Rapids, is engr.

Wis., Milwaukee — Milwaukee Electric Railway & Light Co., Public Service Bldg., awarded contract for construction power house addition, Edison St. to Dahlman Constr. Co., 455 Bway. Estimated cost $40,000.

Wis., Stevens Point—A. L. Shaftona Co., South 2nd St., will build cold storage warehouse by day labor. Estimated cost $50,000.

Wis., Stoughton—Low & Low, 1st Central Bldg., Madison, Archts., taking bids for the construction to boiler and heating plant, at Martin Luther Home. N. A. Stubjoer, Supt. Estimated cost $40,000.

B. C., Fernie—East Kootenay Power Co., A. B. Sanbourn, Gen. Mgr., having plans prepared for new 5,000 kw. auxiliary steam plant. Estimated cost $1,000,000. Private plans.

Que., Montreal—Montreal Rail & Harbor Terminals, Ltd., subsidiary Canadian Pacific R.R. Co., will receive bids in July for the construction of terminal warehouse and cold storage plant at Craig St. East. Estimated cost $5,000,000.